THE
HAWAIIAN
PLANTERS' RECORD

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A monthly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the plantations of the Hawaiian Sugar Planters' Association

Our Watershed Forests.

In this issue we begin the publication of a series of pictures to help acquaint the readers of the *Record* with the forests on which we depend for our water supplies. We wish to show watersheds in prime condition as they exist in some of our mountain areas. We also wish to show the lamentable state of deterioration of the forests of other sections. Once the public becomes aware of the importance of forest cover in conserving water for fluming, irrigation, and domestic purposes, and as a contributing factor for normal rainfall, we believe that the Board of Agriculture and Forestry and others who are allied with them in this work* of conserving our natural resources, will gain the good will and support of every resident of the Territory who has the future of the Islands at heart.

In attempting to depict forest conditions we are particularly fortunate in having the cooperation of Mr. J. F. Rock of the College of Hawaii, who has made remarkably fine photographs of our forests in his intimate study of the flora of the Hawaiian Islands, and who lends them to us for reproduction.

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* 18:359 367, April, 1918.

Yellow Stripe Disease in Porto Rico.

In a previous issue* of the *Record* we reprinted an article dealing with the Yellow Stripe Disease in Porto Rico. The statements therein contained clearly show that the disease is causing very serious damage in the cane fields of that island.

Circular No. 14 of the Porto Rico Experiment Station, recently issued, contains two additional articles on Yellow Stripe disease. These are printed in Spanish, but Mr. Colón, the Director of the Experiment Station, has kindly supplied us with literal translations of both, and we reprint them in this issue of the *Record*.

Does the Insurance Cost Too Much?

Our morning mail brings a post-card which reads:

> "*Yields are limited* by the shortage of any one of the necessary plant food elements, just as the capacity of a tub for holding water is limited by its shortest stave."
>
> "*By using complete fertilizer* you insure yourself against a shortage of any of the necessary elements. Your fertilizer should now contain Nitrogen, Phosphoric Acid, and Potash."
>
> "*The Pacific Guano and Fertilizer Co.*"

We agree with the P. G. & F. Co. that the use of complete fertilizers is excellent insurance against a shortage of any of the necessary elements. But how about the premium we pay for this insurance? Potash and phosphoric acid cost the sugar planters a million dollars a year under pre-war prices and pre-war conditions. If you have a lot of buildings, some of them absolutely fire-proof and others utter fire-traps, and can't take the trouble to find out which is which, insure them all and call the money well spent.

If, on the other hand, you handle your affairs on a business-like basis, you will ascertain the insurance requirements of your properties. Likewise, if we are going to run our agriculture in a business-like way we will find out, even at a considerable expense in soil surveys and field tests, which of our lands actually benefit from phosphoric acid and potash, and not keep on spending a million dollars a year in insurance premiums when half a million a year might be saved.

We like the little comparison about the tub—it is an apt one—only we would call attention to the fact that about nine out of ten of your tub staves are nitrogen staves. If any of these are shorter than the phosphoric acid and potash staves—and they are apt to be—your tub is not going to hold any more water if you lengthen your longer staves. But this is nothing more than

* 18:359-367, April, 1918.

the P. G. & F. Co. means in saying "the capacity of a tub for holding water is limited by its shortest stave."

What we urge you to do is to cooperate with us in finding out which staves are short and to devote your energy and funds to building up these to a level with their fellows. It is more business-like than building them *all* a little higher, regardless of their length.

Mainland Quarantine Against Sugar Cane from Hawaii.

Under the decision of the Federal Horticultural Board acting through the authority of Congress, the Islands are prohibited from shipping sugar cane or any parts of the sugar cane plant such as leaves, bagasse, etc., to or through the mainland of the United States.

We recently applied to Dr. C. L. Marlatt, Chairman of the Board, for a specific interpretation of the laws and rulings pertaining to the case. He writes:

"Under no circumstances should you ship to the mainland any sugar cane or other quarantined articles until a permit from the Secretary of Agriculture, countersigned by myself and one other official of the Board, has been received by you."

WHITE GRUBS IN PORTO RICO.

In a recently issued circular issued by the Insular Experiment Station, Porto Rico, dealing with the "white grub" attacking sugar cane (an insect allied to our *Anomala*), it is stated that this insect is on the increase in 70 per cent of the territory.

"The white grubs occur in all sections of the island, but are particularly abundant in the Guanica and San German districts, where the growing of ratoon cane has been made impossible by their ravages. Although efforts are being made to control these pests in some parts, it is undeniable that they are increasing rapidly and concentrated efforts are necessary to hold them in check."

In discussing control measures it is stated that:

"Chemicals and soil insecticides are not very practical or successful in controlling the white grubs.

"Collecting the white grubs and the beetle is the best method now known of controlling them.

"The protection of the wild birds will be a big factor in decreasing the number of white grubs."

"The introduction of fungus diseases of the white grub has not proved to be effective, while the attempted introduction of parasites from foreign countries has as yet given no results."

When we compare this with the success we have achieved by the introduction of *Scolia manilae,* due to the peculiar biological conditions prevailing in our islands, it emphasizes the necessity of maintaining those conditions as undisturbed as possible. This can only be done by strictly guarding against the introduction of undesirable animals of every kind. There are certain beetles and wasps which prey upon *Scolia manilae* which if introduced into these islands would undo the greater part of the good work achieved.

F. M.

NEMATODE INJURY TO SUGAR CANE IN FLORIDA.

Ten stalks of sugar cane extremely heavily affected with *Heterodera radicicola* were recently received at the office of Sugar Plant Investigations, Bureau of Plant Industry, from River Junction, Florida. The cane had been grown in light, sandy soil and most of the roots of each plant were available for examination. The injurious results due to the attack of nema were to be seen in all parts of the root system. All samples were badly infested, some of the young stalks manifestly had died, mainly, perhaps fully, as a result of nema attack. While one or two of the root systems showed an abundance of small feeding roots, in most cases the number of these were below normal and in some cases they were very few. In most of the root systems the greater portion of the larger roots were already dead or nearly so and many of these were so decayed that their previous condition as to nema infestation could not be accurately judged. The main roots of three of the stalks were counted and classified and it was found that of about 356 roots, approximately one-half were dead, while of those alive 45% had well developed galls. So far as is known, this is by far the worst case recorded on cane. It has usually been considered that this pest is not a serious one on this host. It has been observed in various cane growing regions (Java, Australia and Hawaii), but has never been reported as doing damage to an extent comparable to that exhibited by these specimens from sandy Florida soil.—*The Plant Disease Bulletin, Vol. II, No.* 13.

THE USE OF INSECTICIDES AGAINST LEAFHOPPERS.

By F. Muir.

The use of insecticides to keep down leafhoppers has recently been brought forward for discussion. The reason why the Station entomologists have not undertaken work along these lines is not from ignorance or neglect, but from knowledge and after due consideration.

The use of poison gas in human warfare has suggested its use against insect pests to many persons. Three years ago experiments with chlorine gas were undertaken in the Philippine for the suppression of locusts. The discovery of a gas that would work effectively in the open would be a great boon to economic entomologists. It would revolutionize a number of the existing methods and enable us to undertake work which at present is not practical.

Insecticides which require an enclosed space to act effectively have a limited range of action. The possibility of their use to control the leafhopper was considered in 1903-1904 and reported upon unfavorably. The efforts of the Station were therefore directed to parasites. We depended upon natural enemies to control the leafhopper and their work is a 90% success. The question is—What can we do with the 10% remainder?

Every year there are a certain number of "outbreaks" over limited areas. Most of these pass off without any appreciable damage to the cane, fully controlled by the parasites; a smaller number cause some damage before the parasites can control them, and a few remain which do considerable damage. It is upon these local areas, or pockets of leafhoppers, that the use of insecticides has been suggested.

The question is not as to the possibility of destroying the leafhoppers in these areas with insecticides. This we know can be done. There are well tried insecticides which could be used and various appliances, or should these appliances not be suitable to our conditions it is a simple matter to devise others that would be. The question is as to whether an insecticide is the most efficient and practical method in the long run.

Considering that we depend upon natural enemies to control ninety per cent of our hoppers, and no known insecticide can take their place, it appears logical that on the ten per cent remainder we should use methods that work along the same lines as

the natural enemies, or at least do not work against them. Insecticides destroy friend and foe alike.

It would be difficult to decide when it was necessary to start in with insecticides, because the majority of the outbreaks are perfectly controlled by natural enemies, and to use insecticides in these areas would not only be a useless expense but it would be directly harmful, for these areas are centers of parasites as well as of leafhoppers. To await such time till it can be demonstrated that insecticides are necessary would often be to wait too long to accomplish much good. To increase the parasites in these areas would, at the worst, only be to "take a few more coals to Newcastle."

In considering the control of the leafhopper by natural enemies, the egg parasites must not be the only factors considered. Although these are most numerous, and play the greatest part, there are certain conditions when they alone would take too long to bring about the desired results. We have in our fields other factors in the shape of dryinids, pipunculus flies, predator wasps, spiders, lady-bugs, kissing-bugs, long-horned grasshoppers, earwigs, etc. Had we not had these factors our losses in the early days of leafhopper attacks would have been greater. It is among this class of enemies, foes of the young and adult hoppers, that we hope to discover new allies in Australia or elsewhere. When the hoppers increase to a serious extent through conditions unfavorable to the egg-parasites, it is to the enemies of the young and adult that we must look for a speedy reduction. Insecticides will be more harmful to these than to the egg-parasites, as it will kill off the young as well as many of the adults.

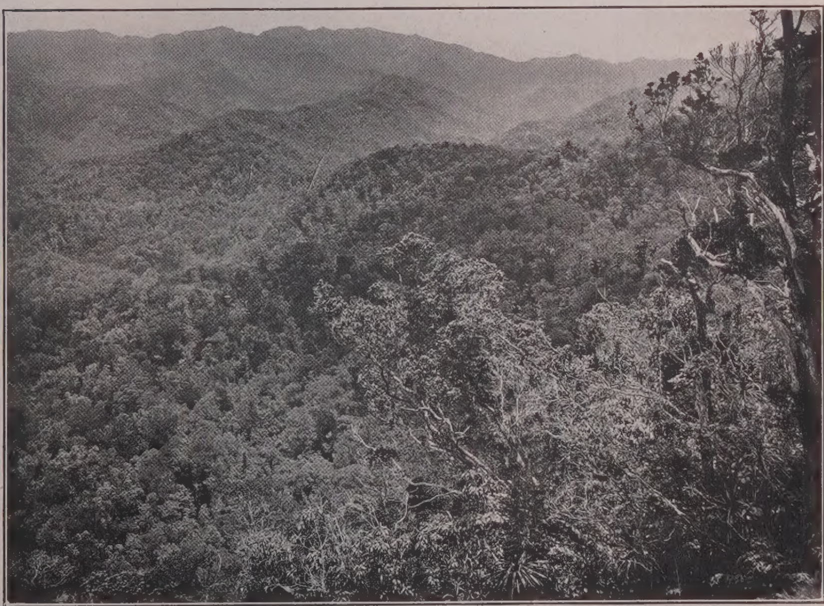
Another method, which has the same results as an increase of natural enemies, is to reduce the hoppers without interfering with the parasites. Such a method has been devised at Olaa in the form of a catcher drawn over cane before it is too high. This can be so devised that while the hoppers are caught most of the parasites can escape.

With a fuller knowledge of the biology of the hopper and natural enemies it is probable that other methods along these lines can be devised. Already some have been suggested and are now under consideration.

Until the greatest use possible has been made of the natural enemies and they have failed us, I consider it a mistake to take to insecticides.

PRESERVE THE REMNANTS OF OUR NATIVE FORESTS.

There are water-conserving native forests still covering areas of considerable extent in these Islands, as the accompanying pictures clearly show. These forests are doomed to destruction if prompt protective and constructive measures are not adopted for their preservation.



An extensive forest on Oahu in the Koolau mountains back of Wahiawa.

If we would save what is left of our native rain-forests we must eliminate the cattle now present in them, prevent their further invasion by stock with proper fences, and build barrier forests along their exposed edges. These measures should be instituted at once, not in one small area only, but throughout the Islands wherever there is a native forest of any extent.

Some seem to think that reforestation in these Islands means the immediate replacement of the native trees with foreign stock. Such a course is altogether inadvisable. We should first save

A stream in the forest on the Koolau mountains of Oahu.

Scene in the rain-forest of Hawaii.

View in the rain-forest on Hawaii.
—Photo by Mr. W. M. Giffard.

what we still have in the way of forests and create our new forests on the large areas from which the native forests have nearly or quite disappeared.

At a recent meeting of the Committee on Forestry of the H. S. P. A., the following resolution was adopted:

"RESOLVED, That it is the desire of this Committee that the preservation and extension of the native forest be the main consideration in all planting operations undertaken on our forest areas."

SUGAR PRODUCTION IN JAVA.

Mr. H. C. Prinsen Geerligs reports, in the September, 1918 number of "The International Sugar Journal." the final results of the 1917 Java sugar crop.

He reports the 185 factories working as having turned out 2,008,625 short tons of sugar from 19,128,820 tons of cane. This from 396,440 acres of land. The yields per acre were 48.25 tons of cane and 5.07 tons of sugar. The entire Java crop is plant and is harvested when from 12 to 16 months old. The acreage was increased 3% over the 1916 crop.

The tonnage of cane and sugar per acre was better than during any of the ten preceding years, or of any preceding year except 1907, when it was about the same.

These exceptional yields were due in part to favorable meteorological conditions, but Mr. Geerligs also remarks as follows: "It should, however, be understood that in 1917 a number of varieties, raised from seed, were harvested, which, owing to their superior qualities, greatly contributed to the extraordinarily good results."

We have here another example of the results possible from seedling work.

In the following table, we give the results of the last ten crops in Java:

JAVA SUGAR CROPS* (1908-1917).

Yrs.	Tons Cane per Acre	Sugar Extracted Per Cent Cane	Tons Sugar per Acre
1908	47.10	10.00	4.71
1909	45.51	9.97	4.54
1910	43.71	10.33	4.52
1911	46.97	10.26	4.82
1912	46.51	9.63	4.48
1913	46.63	9.65	4.50
1914	45.77	9.28	4.25
1915	42.55	9.15	3.89
1916	46.04	10.03	4.62
1917	48.26	10.50	5.07

[J. A. V.]

* Tonnage given in short tons, (2000 pounds).

THE FORDSON TRACTOR.—WHAT WILL IT ACHIEVE ON THE SUGAR PLANTATION?

The agricultural world generally has awaited with some interest the appearance of the tractor developed by Henry Ford, and now marketed under a trade name, the "Fordson." It is said that Mr. Ford at an early stage of his undertaking to supply the farm with a simple, practical, economical tractor, discarded the "track-laying," or "caterpillar" running gear, on the score of inefficiency, and developed a frameless wheel tractor, with many original features. We have heard of the reception given this device in Europe, coming as it did in quantities to relieve a dire situation in food production. We have also learned that the tractor has been accredited by disinterested experts as an ingenious piece of mechanical engineering. On the other hand, we know here in Hawaii of the rapid advances in fulfilling the needs of the sugar plantations by the tractors which lay their own roadway—the caterpillar or track-laying type. The success achieved by the Holt, the Best, the Yuba, the Cleveland and others, is common knowledge. Of these we know. The Fordson is a new factor in sugar-cane agriculture, and we wait with interest to see what place it will assume in competition. Will it be able to find its way about the rough fields and steep slopes that characterize most of our plantations? Will it take the place of the "caterpillar" to any extent? Or will it find a field of usefulness alongside of this established type in still further taking the place of mule-flesh? Another year should give some definite indication,

for we now learn that the Fordson has arrived in Hawaii, and that several deliveries have been made to plantations.

For those of our readers who have not read a detailed description of this new traction engine, we reproduce information supplied us by the manufacturers:

The motor, transmission, and rear axle are assembled together, forming one rigid unit, which, combined with the three-point suspension, relieves these parts of all strain.

The absence of any frame gives accessibility to all parts for making adjustments or repairs, and allows the tractor to be taken apart in a few minutes.

The motor is of substantial design and is capable of delivering its full power continuously. It embodies features which have been used with success in other fields for many years.

PERFORMANCE. The tractor is designed as a two-plow machine and will pull two 14-inch plows in the stiffest soil. It will maintain a drawbar pull of 1800 pounds at plowing speed. In low gear a drawbar pull of 2500 pounds is obtained.

The fuel consumption varies with conditions; two and one-half gallons of kerosene per acre being a fair average. The amount of ground plowed also depends on conditions; eight acres in ten hours would strike an average.

When used at stationary work and running at full power, at 1000 R.P.M., the fuel consumption does not exceed two and three-fourths gallons per hour. The total weight of tractor is 2700 pounds, with water and fuel tanks filled. Over-all length is 102 inches, height 55 inches and width 62 inches.

ENGINE. Four cylinder, four cycle, cylinders are cast bloc.

Cylinder bore, four inches; piston stroke, five inches.

Removable Cylinder Head. This allows easy access to the valves, pistons and cylinders; the crank case is easily removed so that all interior parts of the engine may be reached without taking the tractor apart.

Horsepower. The engine develops twenty-two horsepower when running at 1000 revolutions per minute, and using kerosene.

Lubrication. Splash system; the oil circulation is maintained by the centrifugal action of the flywheel on the oil in the flywheel casing.

COOLING. *Thermo-Syphon System.* The very large water jackets and radiator tanks used with a vertical tube radiator insure a continuous flow of water and efficient cooling. This works in connection with a belt-driven ball-bearing fan.

IGNITION. *Special Design Magneto,* built in and made part of the motor, used in combination with four coils and a commutator. This system is simple and reliable.

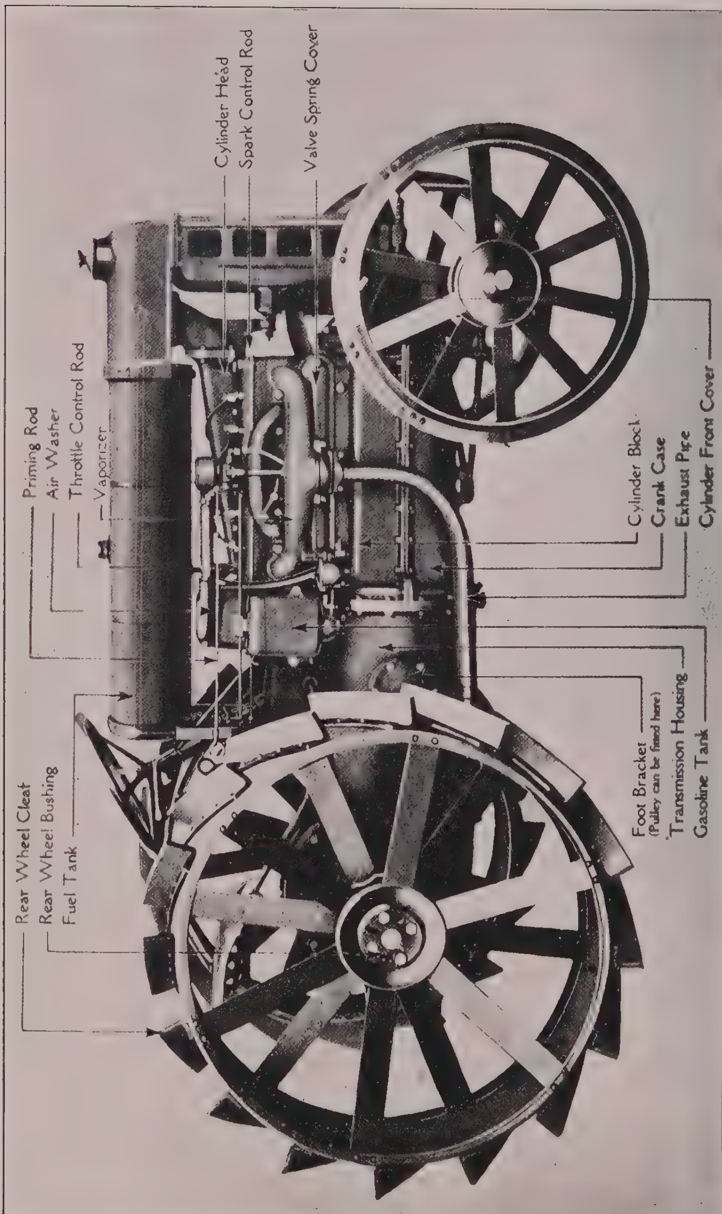
CONTROL. Steering is by bevel pinion and sector, being entirely enclosed and lubricated by oil splash. The steering wheel is located in the center of the tractor. Directly under it is the throttle level. The spark lever is mounted on the dash.

The gear shifter lever is on the left-hand side of the tractor, and the clutch pedal on the right.

The seat is directly behind the steering wheel in the center of the tractor, bringing the driver within easy reach of all controls.

CLUTCH. Multiple steel disc running in oil.

VAPORIZER. Tractor is equipped with a special design vaporizer, which heats the kerosene vapor, and mixing it with fresh, cool air, supplies a dry



The Fordson Tractor

explosive mixture to the cylinders. To start the engine gasoline is used, and after about one minute, when the vaporizer is sufficiently heated, it is shifted to kerosene.

Fuel is supplied by gravity from a twenty-one-gallon overhead tank.

AIR WASHER. The air supply is drawn through water. The wear on the cylinder walls is thus greatly reduced because of all dust having been removed from the air.

TRANSMISSION. Constant mesh, selective type, three speeds forward, and one reverse; all shafts run on ball bearings. Gears are made of vanadium steel and hardened. Final drive is by worm and worm wheel. All gearing is entirely enclosed and runs in oil.

DIFFERENTIAL. Four pinion bevel type and is carried on ball bearings.

REAR AXLE. Is of vanadium steel and rotates in roller bearings on the outer ends.

FRONT AXLE. "I"-beam section. Drop forging made of vanadium steel. It is attached in the center directly to the front of the engine, giving a three-point suspension to the tractor.

WHEELS. Front wheels have steel spokes cast in the hub and riveted to steel rims. They are mounted on ball bearings.

Rear wheels also have the spokes cast in the hub and riveted to the rims. These rims are 42 inches in diameter, 12 inches in width, and are fitted with special cleats designed to give proper traction in the field. By withdrawing a tapered bushing from the hub, the wheels are quickly removed. Wheel base is 63 inches, tread between wheels being 56 inches. The tractor will turn in a 21-foot circle.

TRACTOR SPEEDS. Plowing speed is 2¾ miles per hour; high speed, 6¾ miles per hour; and reverse speed, 2½ miles per hour. This is calculated on engine speed of 1000 R.P.M.

H. P. A.

DETERMINATION OF THE EFFICIENCY OF THE MACERATION.

By R. S. NORRIS.

In a former number of the *Record** I gave a formula for calculating the efficiency of the maceration water applied at the mill. In recent years I have been using a simple method for determining roughly the efficiency of the maceration at any particular mill in the train, which has given me valuable information on this part of the mill work. No change is necessary in the operation of the mill for making a test.

By means of a cup with a very long handle—I generally use a small tin can fastened to the end of a stick 5 to 6 feet long—samples of juice dripping from the front and back

* Vol. 1, page 10.

rollers of the mill are collected simultaneously, the mill running as usual. The sampling is continued for from five to ten minutes, the cups being emptied into a bucket as they fill. The samples are then cooled, the air removed and the Brix determined.

It is manifest that with complete admixture of the maceration water or returned juice with the residual juice in the bagasse, the Brix of the juices from the two rollers would be the same. The ratio of the two densities will therefore represent roughly the degree of admixture.

The ratio may be affected by other factors than the efficiency of the maceration and is therefore not an exact measure of the latter. With the same percentage admixture, if the relative extraction of the front and back rollers should vary for any reason, it would affect the ratio. But practically it is found that unless some change is made in the mill which affects the admixture of the maceration water, the ratio remains fairly constant. The change may not necessarily be in the method of macerating. A finer disintegration of the cane, for instance, by a mill will by itself increase the efficiency of the maceration following that mill.

The ratio is normally always largest for the last mill and decreases for each succeeding mill toward the front, on account of the increasing density of the maceration juices.

A characteristic series of ratios from a twelve roller mill having a high maceration efficiency is the following:

Mill	Brix of Juices		Ratio
	Front Roller	Back Roller	
2	12.1	13.4	1.11
3	4.3	5.5	1.28
4	1.4	4.1	2.93

Other tests gave results as follows:

Test	Mill	Brix of Juices		Ratio	Efficiency
		Front	Back		
1	2	13.3	14.5	1.09	very good
	3	7.5	8.8	1.17	" "
	4	2.4	3.7	1.54	" "
2	2	12.4	13.6	1.10	" "
	3	5.3	6.6	1.18	" "
	4	2.0	4.1	2.05	good
3	2	13.3	15.1	1.13	"
	3	8.5	10.0	1.18	very good
	4	2.3	4.3	1.87	good
4	2	7.4	9.3	1.26	fair
	3	3.5	6.5	1.86	poor
	4	0.9	2.7	3.00	"
5	2	6.9	9.4	1.30	fair
	3	2.8	5.7	2.04	very poor
	4	1.1	2.5	2.27	good
6	2	6.5	9.3	1.43	poor
	3	2.7	5.3	1.96	"
	4	0.8	2.2	2.75	fair
7	2	7.0	9.7	1.39	poor
	3	3.8	5.5	1.45	good
	4	0.8	1.6	2.00	"
8	2	6.7	9.0	1.33	fair
	3	3.0	4.7	1.57	"
	4	0.8	2.2	2.75	"

Abnormal results are sometimes obtained showing a higher ratio on earlier mills than on later ones. This can only happen when there is a marked difference in the efficiency on different mills.

Test	Mill	Brix of Juices		Ratio	Efficiency
		Front	Back		
9	2	8.5	11.6	1.36	fair
	3	2.4	5.1	2.13	very poor
	4	0.6	0.9	1.50	" good
10	2	9.2	12.1	1.31	fair
	3	3.1	5.4	1.74	poor
	4	0.9	1.3	1.44	very good
11	2	12.7	16.0	1.26	good
	3	6.3	9.6	1.52	fair
	4	3.8	5.8	1.53	good
	5	2.9	3.4	1.17	very good
	6	1.6	2.2	1.38	" "
	7	0.5	1.6	3.20	poor
12	2	14.7	17.8	1.21	good
	3	5.4	8.9	1.65	poor
	4	4.0	7.2	1.80	fair
	5	2.7	3.2	1.19	very good
	6	1.3	2.0	1.54	good
	7	0.7	1.4	2.00	"

A single test shows only what the efficiency is at that particular time; it may vary somewhat with the feed. Several tests should therefore be taken to find the average efficiency.

As an example of the effect on the ratio of a change in the method of applying the maceration, I would refer to tests 1 to 8. These were all made at the same factory under two different systems of maceration; tests 1, 2 and 3 under one system, and 4 to 8 under another, less efficient, system.

CHOICE OF MATERIAL FOR ISOLATING INFLORESCENCES IN SELECTION WORK.*

The nature of the covers used to isolate the inflorescences is not without influence on the fructification because a certain amount of light may be necessary for the normal development of the seed, especially at the beginning of setting, as was observed by Scholtz for the poppy and Lubimenko for the pea and wheat.

The author made similar observations for: *Triticum sativum*

* Fruwirth, C. Zeitschrift fur Pflonzenzucht, Vol. V, pp. 391-395, 1917, Berlin.

(winter and spring wheats); *Hordeum distichon erectun* and *H. distichon nutans. Pisum arvense* and *P. sativum. Phaseolus vulgaris, Papaver somniferum, Arrhenatherum elatius.* During his investigations he used covers of various strengths, from parchment bags, which allow the light to pass fairly well, to small wooden boxes lined with black paper used for wrapping up photographic plates. In this latter case no seed formed, while with the less stiff and opaque covers the number of seeds formed decreased. On the other hand, the amount of light absolutely necessary is not the same for all plants, but varies from one species to another, as is shown by the table:

	Black Paper Bag		Parchment Bag		No Cover	
	Number of Inflores-cences.	Number of Seed Formed	Number of Inflores-cences.	Number of Seed Formed	Number of Inflores-cences.	Number of Seed Formed
Pisum arvense......	5 flowers	0	5 flowers	8	5 flowers	14
Barley No1CA Imperial	5 ears	55	5 ears	94	5 ears	112
Wheat 104 Criewener	5 "	88	5 "	129	5 "	196

The covers used to isolate inflorescences must, therefore, be fairly transparent as the absence of seeds formed is often attributable to insufficient light rather than phenomena of self-sterility. (J. A. V.)

ERADICATION OF THE YELLOW STRIPE DISEASE OF SUGAR CANE.*

THE YELLOW STRIPE DISEASE.

By E. D. Colón.
Director, Insular Experiment Station.

The mottling disease of cane began to call the attention of this Station during the year 1915-1916. The disease was then thought to be a new and unknown one and as such it was studied

* Circular No. 14, Insular Experiment Station, Rio Piedras, Porto Rico. Translation supplied by E. D. Colón.

until February, 1918, at which time it was heard on this Island that Dr. H. L. Lyon of Hawaii, was of the opinion that the disease described by the Pathologist of this Station, Mr. J. A. Stevenson, corresponded with another one already known and studied in Java and in Hawaii by the name of the Yellow Stripe Disease. Recently the said Dr. Lyon, while visiting Washington, had the opportunity to examine samples of mottled cane sent there from this Island, and once more he ratified his diagnosis. The Director of this Station obtained and had translated the most complete article existing about this disease, published by the Sugar Experiment Station of Java. The descriptions therein given are very much like the disease here in question.

Considering the statements and until something else is proven it seems justified to accept the identity of our mottling disease with the Yellow Stripe of Java and Hawaii.

This explanation is made with a fixed purpose. The belief that the disease was something new and that nothing was known about it anywhere has been a great obstacle toward accepting the facts established in relation with it, in this Island and outside of this Island, and towards undertaking with enthusiasm the campaign of eradication recommended by this Station. Let us overcome the obstacle. Let us consider the facts:

1. *The characteristic mottling of the disease becomes more difficult of detection as the plant reaches its stage of maturity.*

The article of Java reads:

"As the plant becomes old, along with its development diminishes also the distinctness of the phenomenon."

2. *The disease reduces the tonnage, and consequently, the production of sugar per "cuerda."*

The following results were obtained in an experiment made in Java.

Healthy cane: 21.23 tons per acre, first crop.
Diseased cane: 18.20 tons per acre, first crop.

Another experiment in Hawaii gave the following results:

	Tonnage of 3 Rows of 80 feet.	Tonnage Estimated per Acre.	No. of Canes.	Average weight of each Cane. (Pounds.)	Tonnage of Sugar per Acre.
Healthy cane..........	2.786	101.13	835	9.27	14.98
Diseased cane.........	1.5495	56.24	623	8.01	8.43

3 *Neither fertilizer, irrigation or intensive cultivation will cure the disease.*

The experience obtained by the cane growers of the north and northeast coast of the Island, of the Station, Central Fajardo and Java leaves no doubt as regards to the above statement.

4. *The disinfection of the seed with Bordeaux mixture, lime, formalin and bichloride of mercury has no effect upon the diseased seed.*

From the experiences obtained in the Central Fajardo 100% of diseased seed gave 100% of diseased shoots after having received the above treatment.

5. *Not all varieties of cane offer the same degree of resistance to the disease.*

According to Dr. H. L. Lyon, in Hawaii the *Rayada**, *Nueva Guinea,* 15†, and Demerara 1135 are very resistant. The Demerara 433 has resisted the disease in Fajardo; in the experiments made by the Department of Agronomy of this Station, the varieties Barbados 4596, Barbados 3412 and Caledonia Amarilla‡.

6. *The disease is of a hereditary character: almost absolutely diseased seed gives diseased cane.*

Of the total 623 canes coming from diseased seed shown in the experiment carried out in Hawaii, (No. 2) above mentioned, only three could be taken as apparently healthy.

Another experiment carried out in Java gave the following results:

Percentage of Diseased Shoots in Each Plot.					Average of 2 Enumeration.		
Variety.	Percentage of Diseased Seed Planted.	Plot No. 1	Plot No. 2	Plot No. 3	Plot No. 4	Plot No. 5	Plot No. 6
G. Z.	100%	100%	100%	95%	100%	98%	99%

7. *The disease spreads, sometimes slowly, sometimes with great rapidity; but it spreads always.*

In the experiment made in Hawaii, above mentioned (No. 2), 12% of healthy canes became diseased during their growth.

In another experiment carried out in Java the diseased plants were counted twice: on December 2 and on February 16. At the time the second enumeration was made it was found that in December the disease was beginning to develop, an important in-

* Striped Mexican. † Badila. ‡ Yellow Caledonia.

crease of diseased plants having been observed in February, in some cases as far as 25%.

8. *The infection is not transmitted through the soil; so that the mere fact that diseased cane has been grown in a soil does not influence the degree of infection in a subsequent planting.*

In Java, the following results were obtained in planting the variety G. Z. 247 respectively in soil in which diseased cane had been planted, in soil planted with healthy cane, and in soil where cane had never been planted.

Enumeration.	Soil Where Healthy Cane Had Been Planted	Soil Planted with Diseased Cane.	Soil Never Planted.
1st.	2.6 %	3.6 %	3.3%
2nd.	21.25%	22.35%	16.475%

In the Central Fajardo, the varieties Caledonia Amarilla, Demerara 433, Rayada and Barbados 3412 were planted on July 31, 1918, in holes immediately after removing from them diseased cane. The 18th day of September following none of the new shoots was found diseased.

9. *The disease, approximately, has become general in the cane fields of the Island to the West of an imaginary line drawn from Bayamón in the North as far as Guánica in the South. To the East of this line only isolated diseased stalks and fields are found.*

It is plain then, that the disease must be checked because it unfailingly reduces the tonnage.

In order to check the disease it is necessary to know it. Examine the colored plates found in this pamphlet; let the field superintendents and cane workers know it.

In order to exterminate the disease we have to destroy the sources of infection.

As the infection is not carried through the soil the work is simplified: the infection is carried by the plant.

Then we must direct our attention to the plant.

As the disease is hereditary, do not plant diseased seed.

As the disease is mostly spread to the West of the imaginary line from Bayamón to Guánica, be on guard when using seed from that district.

To avoid mistakes in the selection, select while the cane is still standing.

As the disease is propagated from diseased plants to healthy plants, inspect the fields continually, remove the diseased ones,

burn them and replant with healthy seed, if it continues, for the disease is not found in the soil.

As the mottling can be distinguished more easily in young plants and in this period there is opportunity to replant, examine always with preference the young-planted fields.

DIRECTIONS FOR ERADICATING THE MOSAIC DISEASE OF SUGAR CANE.

By F. S. Earle

Pathologist, United States Department of Agriculture.

The mosaic disease* is an infection that is propagated through planting diseased seed cane. A secondary infection also exists by which healthy plants may become diseased at any stage of their growth. This secondary infection is probably carried by insects. The disease is not propagated in the soil. Soils do not become infected. The presence or absence does not in the least depend on the kind of soil, the way in which it is prepared or the kind of fertilizer used.

This disease is incurable. A plant once sick will always be sick. It may live many years, but its growth will be slow and the yield of cane very small. To eradicate this disease it is necessary to start by planting only sound healthy seed. So far as possible diseased plants in neighboring fields should be dug out to destroy contagion and prevent secondary infection. In some cases it may be necessary to import seed from some other districts where the disease does not occur. This is expensive and usually it will be better to plant special fields with carefully selected seed to serve as nurseries for future plantings. The seed for such nurseries must be selected while the cane is still standing in the field. After the leaves are cut off it is impossible to tell a diseased from a healthy seed. Even in the worst diseased fields certain canes can always be seen here and there that are still healthy. Such cases are in part accidental but in part they doubtless represent immune or partially immune strains. The best of these healthy canes from badly diseased fields should be selected and used to plant nurseries to supply seed for the next season's planting. These nurseries should be located as far as possible from fields in which diseased cane is growing and to the windward of such fields. When the seed has germinated the nurseries must be carefully inspected and any diseased seeds that have acci-

* Also known as Mottling disease, La Enfermedad de Arecibo and Mordida de Perro. It is the Yellow Stripe Disease of Java and Hawaii.

dentally been planted must be pulled up. Inspections should be continued as often as once in two weeks for the entire season in order to detect and dig out any cases of secondary infection which may appear. If this is carefully done a nursery of absolutely healthy seed will be secured from which to make the next plantings. Fields for these plantings should be prepared compactly together on the windward side of the plantation. They should not be scattered in among fields of diseased cane. These fields also should be inspected frequently to make sure that all secondary infections are promptly removed.

By rigidly following these instructions an entire plantation can be cleared of the disease in from two to three years' time.

There are only two things to be done, and of these one is as necessary as the other.

1*st*. Plant only the most healthy seed obtainable. Stop propagating the disease by planting diseased seed.

2*nd*. Inspect the fields frequently to remove accidentally planted bad seeds or cases of secondary infection.

The situation is critical. Act now. Do the work of inspection frequently and thoroughly. Failure to act promptly and thoroughly will result in ruin for the cane industry of Porto Rico.

BETTER RESULTS BY BETTER MANAGEMENT.

By L. W. Alwyn-Schmidt.

Chief of Economic Department of the New York Economic Service Bureau.

During the year 1915 the average cost of producing a ton of sugar was in Hawaii $44.59. It was $52.29 in Porto Rico and $28.92 in Cuba. In Hawaii there are sugar factories which produce one ton of sugar at a cost to themselves of $68.026 while others are able to produce for $34.26. In Porto Rico the highest cost of production is $67.02 per ton of sugar and the lowest

$44.02, while in Cuba sugar is produced at anything from $43.77 downward to $22.35. Also Louisiana sugar factors are producing with widely varying results. There are factories in that state which are able to produce at a cost to themselves of $53.95, while others are spending as much as $99.28.

Why this astonishing difference in manufacturing cost in countries which in their essential conditions appear to be similar? Bad quality of cane, will be the explanation of the agriculturist; inadequate machinery, that of the engineer, and bad management will be the contribution of the efficiency expert and accountant to the possible solution of the problem. Then all three will sit down to discuss a likely cure for the disease. Planting methods will be improved, there will be new and improved factory equipment, and a modern system of cost accounting will be instituted. This may bring the desired result in one factory, but it will fail to effect an improvement in the earnings of another because one important factor has been overlooked, that of co-ordination.

Let me explain just what is meant in this case by the word co-ordination. The conditions bearing on the production of cane and its treatment in the mills must be different in each factory. One plantation will grow 16 tons of sugar cane on each acre of its plantations and another 33. One will pay more for sugar cane delivered at the factory door than another. The costs of cultivation, irrigating and harvesting must differ with the local conditions. Less sugar may be obtained from the cane grown in one district than from that grown in another. Factory treatment will be expensive here and less costly somewhere else. When all cost items are added up, there must be an essential difference in the cost of the ready product according to the effect of each item on the total expense. But the manufacturer who pays a higher price for his sugar cane or whose factory production cost is higher than that of his competitors is necessarily handicapped if he has to pay just as much as his competitor for all the remaining items influencing the total cost of production. He can overcome this initial handicap by reducing the cost of one or the other factor of his cost bill to such an extent as to neutralize the cost increasing effect of the non-competitive item.

To take for argument's sake the case of a factory A, which pays for a quantity of the cane as delivered at the factory door $30.00 while the remaining manufacturing cost is $70.00, including profit. This factory can sell at $100.00. If factory B buys the cane at $40.00 and also has to make $70.00 pay for manufacturing the sugar and profit, its sales price must be $110.00.

Factory B, however, by employing first class machinery, by increasing the production or by any other means, may reduce manufacturing cost to $60.00. In this case it would be possible to sell the product at $40.00 price of cane plus $60.00 manufacturing and profit, which is $100.00. B, in this case, co-ordinates the individual expense items in such a way as to produce the same total result as A.

Co-ordination of the individual expense factors may be effected in many different ways. It must be applied not only to co-ordinate the principal factors of cost of production, as price of materials, fuel, wages, rent, etc., but also with reference to the component cost items of each of the grand totals. So the cost of planting cane may be reduced by using machinery with a view to allow some leeway in paying more for irrigation; or more fertilizer may be employed to raise the general efficiency of the cane product and in this way make up for the high cost of producing the crop. Harvesting methods may be improved in such a way as to reduce the cost of the cane as delivered at the factory. In mill production the influence of high wages can be neutralized in the interest of co-ordination by employing labor saving machinery. The machinery can be employed for the purpose of eliminating waste caused by inefficient methods which adds to the total production and reduces the cost of the produced unit. But whatever is done, must be done in a haphazard way. It must be done with a definite purpose in view. It is certainly not to the advantage of a factory to reduce the cost of one item and by doing so lose on productive efficiency in another direction. The final result, that of actual cost of the produced ton, must be the decisive test of successful co-ordination.

In approaching the difficult problem of how to co-ordinate the individual expense items in his factory in such a way as to make the product competitive, each factory manager will have to do his own experimenting and studying. It is a case where everybody has to work out his own salvation. Most factory superintendents, while quite ready to admit that they are not able to produce at the same cost level as other factories in their neighborhood, are as a rule not willing to concede that their own methods are not efficient. They hold that conditions in their own plant are different from those in the plant of the more favored competitor and that similar favorable conditions cannot be created in their own. This contention is readily conceded by the writer, but he also is confident that even under the most unfavorable conditions improvements will be possible and that these improvements when applied at the right spot often will lead to a complete correction of the trouble. In all difficult cases expert opin-

on should be appealed to, not because the outside expert is likely to know more about the factory and factory methods than the owner or manager, but because he is likely to take a more dis-associated view of the problems of the factory and therefore will be more readily able to locate the fundamental trouble.

The first and principal step to be taken in cases where inefficient methods are suspected, is to compare the results of the plant with those of others in the same district. Unfortunately for the manager his competitors are not always willing to come to his assistance, either because they are not quite satisfied about their own situation, or because they have a natural disinclination to make free with their own experiences. If local comparisons can be made, the best local standard should be used for measuring the results of their own enterprise. Only by striving for the best can we improve our own situation. If no local standards can be made available the next best are those of the national average of factory efficiency. Such national averages can be deduced as a rule from census reports and similar official information, collected by local or national enterprise. In comparing the situation in one's own factory with the national averages it is not safe to be satisfied if one's own factory reaches merely the national average. A national average naturally takes into consideration both the best and the worst examples of national production, and it, therefore, inclines rather to favor the less efficient than the most proficient enterprise.

To assist growers and manufacturers in such a preliminary investigation of their production there are given below a number of statistics which may be employed for the purpose of testing the efficiency of their own methods.

To take at first an American example. Below is the expense and income account of an average American sugar factory. This has been compiled by analyzing the American census figures of 1914. Small corrections were only made with a view of bringing the account into the range of ordinary factory conditions.

Capital $180,000			
Expenses:			
Officials (2)	$ 4,000		
Clerks (1)	900		
Wages	8,754		
Contract work	654		
Rent	165		
Taxes	1,356		
Cost of material.........	82,357		
Fuel	6,350		
	$105,536	Income............	$120,195

This imaginary factory produces at a cost of $105,536 a quantity of sugar that can be sold at a value of $120,195, at the door of the factory. It employs two superintendents besides manager, assistant manager and one clerk. During the high peak of the season 76 men are at work. There is a total primary power development of 630 h.p. of which 626 h.p. are steam-generated, but there are also a few small power units required for driving special machinery which use either gasoline or electrical power. There is a coal consumption of 1822 tons and oil is burned at the rate of 4667 barrels.

And here are some more average figures dealing with conditions in Louisiana, Hawaii, Porto Rico, and Cuba:

	Hawaii	Porto Rico	Louisiana	Cuba
Cane production per acre:				
Average for all plantation, tons....	43.92	20.45	18.29	21.32
Highest plantation production.....	65.87	24.99	24.73	31.53
Sugar production per acre:				
Average for all plantations, pounds.	10,992	4 539	2.616	4,912
Highest plantation production.....	16,800	5,653	4,080	7.300
Tons of cane required to produce one ton of sugar:				
Average for all plantations, tons...	8.14	9.01	13.96	8.68
Lowest plantation	6.84	7.93	10.93	7.69
Yield of sugar per ton of cane:				
Average for all plantations, pounds.	245.63	221.87	143.26	230.42
Highest plantation yield..........	292.09	252.13	182.93	260.24
Cost of cane at mill per ton of cane:				
Average for all establishments.....	$4.66	$4.62	$4.27	$2.37
Lowest establishment cost........	3.34	3.78	3.45	1.83
Manufacturing costs:				
Average for all establishments.....	6.81	12.08	19.32	8.99
Lowest establishment cost........	4.77	8.66	10.80	5.38
Cost of production f.o.b. factory per ton of sugar:				
Average for all establishments.....	44.59	52.29	79.50	28.92
Lowest establishment cost........	34.26	44.02	53.95	22.35

It is not always easy for the average manufacturer to analyze production cost so finely as to make possible a comparison with these figures. Nevertheless, the attempt should be made in the interest of efficient management and increased profits. The results of a preliminary test of factory results like that proposed here, by the way, need not be absolutely conclusive. All that is required for the first is a general impression of the situation of the factory for the purpose of a comparison.

To get, for instance, at the cost factor of each ton of sugar produced in a factory is comparatively easy. The total expense is divided by the number of tons sold. This test should not be made for one year only, but it should be carried over a number of years. It is more complicated to establish a cost factor for

the sugar cane as delivered at the mill. The reason herefor is that conditions under which the cane is obtained by the mills, change a good deal in each establishment. To provide for this eventuality one should be inclined rather to err in favor of higher cost than lower. Cost of sugar cane at mill must not mean the cost of the cane to the factory, but it must also include the total delivery charges. If a plantation or mill owns its transportation facilities in the form of a plantation railroad or of carts, motor trucks, etc., and carries the sugar cane from the fields to the mill or collects it from the growers, this part of the carrying expenses cannot be charged to general transportation, but it is an essential part of the cost of providing cane for the factory. Therefore, it must be established how much of the existing transportation facilities are employed in that particular part of the service, and a charge must be made when establishing the price factor. This is not easy but absolutely essential or the whole system of cost accounting becomes distorted. A factory charging all transportation to overhead expenses and omitting to include part of it in the cost of the cane as delivered to the mill door would, on the face of it, buy its cane very cheaply, but the result nevertheless would be that it produces more expensively than another factory buying at the same cost but including the transportation charge, provided always that all other conditions of production are the same in both cases. No co-ordination of cost and production is possible unless each item of cost remains absolutely separated from the other.

If the mill has a chemist who also superintends the agricultural side of the enterprise, that part of his work which applies to cane production must be charged to the cost of the cane, while that part that goes into the mill work goes to manufacturing expenses.

Seeing that most of the modern mills are growing their own cane or at least a very large part of it, the question of sugar production per acre is of considerable importance in its bearing on cost accounting. Possibly no factor in cost accounting, by the way, is more elusive than just this. There is no extensive sugar plantation in this world which has soil of an even productive power over the whole area. There is good and medium and rotten land, and the productive results are accordingly. The mill which owns a large acreage of sugar plantation land, as a rule has invested a large part of its capital in land, and it is up to the management to see that the best results are obtained from it. A close observation of the soil and its productive value, therefore, is necessary. All land under cultivation must be of sufficient productive quality in order to make worth while the planting, or, if this should not be the case, it must be improved in such a

way as to bring it up to the required standard. But this work of improvement must not cost more than is justified by the financial results that can be expected, that means, it must be in proper relation to the cost of the cane paid by the factory. If, for instance, the soil can be improved by better working methods and a more intensive application of fertilizers, the relative cost of the sugar cane obtained must not be higher than that amount for which it can be bought by the factory in the open market.

How important it is for a factory to know exactly the productive capacity of its own acreage may be seen from the following: Suppose a factory is in the habit of using sugar cane from its own plantation but augments the supply with cane bought from other growers. How much can the factory pay for the outside cane? Is its own plantation producing the cane at a non-competitive rate? The usual answer to this question will be that the market price should be the test. This, however, is only partly true. The price paid should be the market price modified by the cost of the sugar cane produced by the mill's own plantation.

There will be occasion to deal with this question in the further course of these articles.

It has been stated already that such a preliminary test need not be very accurate. It can be of a general character and will serve for the first only for the purpose of comparison. The principal cost and general factors that may be established in the course of gaining a superficial impression of the state of efficiency in a sugar factory are the following: cane production per acre, sugar production per acre, tons of cane required to produce one ton of sugar, yield of sugar per ton of cane, cost of cane at mill door, cost of manufacturing, cost of production f.o.b. factory per ton of sugar, power required per ton of sugar produced, fuel required per ton of sugar, cost of producing 1-hp. of engine power, number of hp. of engine power employed for each workman employed during high peak of season of factory, production of sugar for each workman employed during the high peak of season in factory.

The first six tests apply to general efficiency. The others deal with the more intimate working of each productive factor in the factory. Compare the results obtained in this way with the standards of efficiency shown in the statistics given above. If they approach as nearly as possible the best standard recorded, one can be reasonably sure that the plant in question is operated on a sound basis and that improvements, if they are desired, can be of a minor character only.

But we are dealing here not with the healthy concern or those

enjoying at least reasonable health, but with those having a hidden complaint that will not allow them to make the same profits and to reach the same efficiency in production as that obtained by competing establishments.

Therefore, if the test shows considerable discrepancies with the performance recorded in the above statistics, there is cause for an extension of the enquiry which now seriously calls for the employment of an expert and will have to take into consideration each single item of production. This enquiry must be as exhaustive as possible and it must go into the most intimate workings of all parts of the productive energy of the concern.

It is very difficult to say where such an enquiry should start. Any beginning really is suitable, but there must be a clear cut wherever the start is made, in order to prevent overlapping of effort and results. The best procedure is probably to separate at first all activities preceding the arrival of the cane at the factory door from those following this. That means, that everything that applies to the production and raising of the cane is left to the first part of the enquiry. Here it must be established what the cane costs to the mill when it arrives at the factory and what the sugar contents of the cane cost. The latter factor is really deciding for the value of the cane to the mill. To make this part of the enquiry of real value for the future management of the establishment, it must not refer only to each component item of production as taking place on the plantation, but also alternative lines of enquiry will have to be followed. When it is possible also to buy sugar cane in the neighborhood the test should not be made only with reference to the cane produced by the own plantation, but should also extend to the sugar cane that can be bought from outside sources. The results of each of the tests then should be compared with a view to see whether it would not be good policy for the mill to change its then existing policy by buying a larger percentage of the cane from outside sources, or whether as an alternative it will be of advantage to extend private growing operations. Such an analysis should not stop at comparing only the final results which of course are of principal bearing, but in the interest of co-ordinating efforts in the production of the cane and increasing efficiency it should cover also the minor operations. So it should be established how much it costs the mill to plant one acre of cane on its own plantations and how much outside growers are paying for the same work. With the same end in mind the cost of planting one ton of cane under both conditions is of interest to know. Other factors of the same character applying to general production of cane are: cost of cultivating one acre of sugar cane; cost of cultivating one ton

	HAWAII		Porto Rico	Cuba
	Irrigated	Unirrigated		
Planting cane:				
Cost per acre:				
Average, all plantations...	$19.17	$13.84	$14.40	$4.24
Lowest..................	8.43	4.41	5.79	0.64
Cost per ton of cane:				
Average, all plantations...	0.40	0.38	0.61	0.20
Lowest..................	0.14	0.11	0.32	0.04
Cultivating cane:				
Cost per acre:				
Average, all plantations...	24.15	46.52	13.82	7.85
Lowest..................	10.45	27.75	5.52	3.04
Cost per ton of cane:				
Average, all plantations...	0.51	1.28	0.59	0.36
Lowest..................	0.16	0.87	0.24	0.12
Irrigating cane:				
Cost per acre:				
Average, all plantations...	67.91	....	15.76	2.18
Lowest..................	12.35	....	10.74	0.35
Cost per ton of cane:				
Average, all plantations...	1.42	....	0.63	0.08
Lowest..................	0.39	....	0.46	0.014
Fertilizing cane:				
Cost per acre:				
Average, all plantations...	40.37	48.82	8.28	2.43
Lowest..................	21.53	26.01	0.31	0.02
Cost per ton of cane:				
Average, all plantations...	0.84	1.35	0.35	0.12
Lowest..................	0.57	0.85	0.02	0.01
Harvesting cane:				
Cost per acre:				
Average, all plantations...	36.03	73.93	16.05	24.53
Lowest..................	21.02	29.80	7.26	12.23
Cost per ton of cane:				
Average, all plantations...	0.75	1.05	0.69	1.13
Lowest..................	0.58	0.77	0.32	0.68

of cane; cost of irrigation per acre and per ton of cane; cost of fertilizing per acre and per ton; cost of harvesting per acre and per ton; cost of transporting one ton of cane to the door of the factory.

To allow comparison there are given opposite the comparative figures for the principal of these factors for Hawaii, Porto Rico, and Cuba, showing the averages and best performances.

There is always a certain amount of waste of cane between the factory door and the mills. The percentage of that waste is very considerable in some mills, but has been reduced to a minimum in many others. With manufacturing methods improving, the elimination of this kind of waste becomes more and more general. To establish its extent in a scheme of cost accounting, nevertheless, remains a necessity. An additional quantity factor, therefore, should be established for cane at the crushing mills.

Following the principle that there should be co-ordination not

only of the principal cost factors but also of all the minor items, it becomes necessary to scrutinize the cost of manufacturing with the same care as has been recommended already with reference to the production of the raw material. But this process of scrutinizing must extend not only to the cost but also to the methods employed by the factory. The higher cost of cane to the mills of Hawaii has compelled these mills to make a more extensive use of up to date machine equipment than is, for instance, the case in Cuba. The result is that the Hawaiian sugar mills extract as a rule a larger percentage of sugar from the cane than the Cuban mills. The Hawaiian mills co-ordinate their efforts, therefore, by adding to the efficiency of production. The Cuban mills have followed apparently a different policy. Buying sugar cane cheaper than their competitors in Hawaii, they are run with less attention to efficiency in sugar extraction from the cane, but with a view to obtain a larger output by a faster operation of their machinery which enables their owners to treat a larger quantity of cane. Whether this is good policy is a question which shall not be decided here. Considering, however, the lower cost of labor in Hawaii as compared with that in Cuba, it may well pay the Hawaiian mill to run slower and to have a larger percentual result than the Cuban factory. The latter might find that the larger quantity of sugar to be obtained by more extensive extraction will not compensate the factory for the higher cost of wages necessitated by the slower process.

In the interest of profitable management and engineering count must be taken of the relative position of the following cost and efficiency factors: Cost of labor, cost of fuel, cost of factory supplies, cost of containers, maintenance of machinery and buildings, insurance rates, taxes, general expense, depreciation of building and factory equipment.

Next to the cost of materials labor is, with a few exceptions, the most expensive individual cost item in a sugar factory. It is therefore very essential to establish not only the cost of labor for each ton of sugar that is manufactured, but also the number of men which is required to obtain a certain production from week to week during campaign time.

In establishing a cost factor for fuel only the cost of the bagasse makes serious trouble. There are factories which make no charge at all for bagasse. Their accountants contend that they have paid already for the bagasse when the sugar cane was delivered at the factory. It seems, however, a better policy to establish a price for the bagasse which, after all, represents a value to the factory. If this is done it will check the tendency to be wasteful with the fuel, which in turn may lead to the installation

of better boiler facilities in many of the older mills, which today seem to burn considerably more fuel than is required when modern furnaces are employed.

Little advantage is gained by one factory over another in the purchase of containers, and the establishment of a cost factor for these is more of a general value. Of considerable importance, however, is the cost factor referring to general factory supplies owing to its near relation to maintenance cost. The expenses undertaken by a factory in the interest of maintenance are made with the view to reduce the depreciation of factory property and to keep up the general productive efficiency of the plant. It seems, therefore, wrong to include under general supplies purchases which are made for the purpose of keeping up the repair status of the plant, as small machine parts, screws, etc., which really should be charged under the proper heading of maintenance cost. Unfortunately very few factories seem to follow this principle, with the result that the factor of general supplies as shown further down in the average statistics appears very much distorted. In how far the purchase of new machinery or additional equipment is properly charged to maintenance is also a very difficult question. I feel not disposed to answer it at this stage of the progress of our work where we are still occupied with laying down the general principles of analytical cost accounting as applied to the sugar industry. The sugar mill owner, while making a general survey of the position of his plant, certainly should not be unduly depressed, should he find that his own averages for maintenance and general supplies do not confirm entirely with those given in the following statistics, as it is not at all clear on which basis they are compiled. There is also a lack of uniformity in the compilation of the factor of depreciation in many factories. It will be time enough to attend to all these points in a subsequent article

In the meantime here are the average figures of cost of mill production in Hawaii, Porto Rico, and Cuba:

	Hawaii	Porto Rico	Cuba
Factory costs:			
Manufacturing—factory labor	$1.61	$3.28	$2.70
Fuel for factory	0.30	1.04	0.75
Sugar containers	1.85	2.29	1.64
Sundry factory supplies	0.55	0.62	0.56
Repair of machinery and buildings	1.20	2.27	1.71
Sanitation, hospital, and welfare	0.16	0.20	0.32
Insurance, taxes, and rent	0.27	0.37	0.20
Factory depreciation	0.85	2.09	1.08
Total factory costs	$6.70	$12.08	$8.96

Future articles of this series will be:

1. Co-ordinating cost of cane production.
   This deals with cost of plantation labor, improvement of planting methods, fertilizing, yield, and the influences on the cost of sugar cane.
2. Price of cane at factory door and mill.
   The question of the cost of cane to the mill will be treated in this article, also the influences of transportation, supplementary supplies of cane, etc.
3. Co-ordination of factory production.
   The principles of co-ordination and cost accounting of the work in the factory will be treated in this article.

To be followed by:

Cost and efficiency of labor.
Maintenance of equipment and its influence on production cost.
Turning a loss into profit.
Fuel and steam efficiency.
Overhead expenses.
Reducing manufacturing expenses by making use of by-products.

THE SEEDING METHOD OF GRAINING SUGAR.*

By H. E. Zitkowski.

There is a disposition in some quarters to deny to the sugar industry its claim as a member of the chemical industrial family. That the beet sugar industry, the direct descendant of scientific research and probably the oldest member of magnitude of the

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chemical industry family, should find it necessary to establish any claims in this direction is anomalous. Someone, sometime, as a labor of love, will bring out this as a matter of record.

Here I desire merely to state that nowhere else in industry has technical accounting been carried to a point as in the beet sugar industry. The beet sugar industry has taken laboratory manipulations or processes such as dialysis or diffusion, precipitation, filtration, evaporation and crystallization and adapted them to factory scale, handling millions of pounds of material daily, and with a refinement which taxes the ingenuity of the most expert manipulator to now duplicate on a laboratory scale.

It is even held that the beet sugar industry, which established itself in Europe during the Napoleonic wars, deserves to a very large degree the credit for the rapid development of the chemical industry of Germany. It was the beet sugar industry which furnished the technically trained and experienced men, capable of transferring laboratory reactions and processes to a factory scale and keep the commercial requirements in mind, when the modern chemical industry sprang into being.

Men go so far as to state that it was the beet sugar industry of Germany which made possible the terrible war that Germany is waging, not only because it was the foundation stone for the chemical industry but also because the cultivation of the beet brought with it scientific agriculture which doubled the agricultural yields, thereby making Germany largely self-sustaining and eliminating the threat of being starved to submission by blockade. There is much that can be said in defense of such a viewpoint.

However, at this time here it is desired to discuss briefly the large scale practical application of the well known "seeding" method of inducing crystallization.

The oldest, and for many years the only method, of producing sugar crystals was to concentrate the properly purified sugar bearing syrups to the required density or supersaturation and set them away. In the course of days or weeks or even months, as the solution cooled, sugar would crystallize out. Even after the introduction of the vacuum pan method of "boiling" sugar, for many years, this was the only method and was known as "boiling blanks." Sometime during the fifties of the last century the art or rather the "trick of the trade" of "graining" sugar while yet in the vacuum pan was acquired though this was not generally adopted till twenty years later, and even up to this day frequently, for reasons which need not be discussed here, blanks are boiled. The general procedure at present is as follows:

A quantity of the properly prepared sugar bearing syrup with a water content of from 30 to 40 per cent is introduced into a

vacuum evaporator or "pan" and is concentrated till saturated. At this point the boiling mass will be at a temperature of from 70° to 80° C., and under a vacuum of from 20 to 25 inches.

Now under certain conditions aqueous sugar solutions have the property of forming supersaturated solutions and in the presence of the non-sugars or impurities such as occur even in purified juices this tendency is greatly increased so that in factory practice it is always necessary to carry the concentration to some degree of supersaturation before crystallization occurs. Now it is not to be inferred that in all cases simple supersaturation will bring about crystallization, for, if the content of non-sugars or impurities in the solution is great enough, crystallization will not occur even though evaporation be carried to the point of dryness.

Under the normal conditions of sugar manufacture, however, that degree of supersaturation is finally reached at which crystal formation begins. Sometimes a sudden shock applied to the boiling, supersaturated mass is resorted to in order to induce crystallization, such as a sudden raising of the vacuum bringing with it violent ebulition, or the introduction of a hot syrup of a lower density which has the same effect, or the injection of steam or air into the mass. No matter how produced, at the moment of their formation the crystals are infinitely small and some time is required to attain a visible size, though this may be only a few moments. Eventually the crystals formed do become visible and then the critical moment of the "boiling" of the "pan" arrives.

It becomes the attendant's business to allow the formation of crystals to proceed till, in his judgment, the proper number of nuclei for the apparatus in question have formed, then to arrest the formation of further crystals by lowering the supersaturation coefficient, which is done by lowering the vacuum, raising the temperature and diluting with syrup of a lower density. From then on it becomes his business to so regulate the temperature, the rate of evaporation and the introduction of syrup that the minute crystals will grow and, when the pan is full, be of the size to supply the market's demand.

Now not much time for deliberation is available when it is realized that often a pan holding 200,000 pounds of mass and yielding 80,000 pounds of granulated sugar is boiled complete in less than two hours. If the operator's judgment at the time of "graining" is at fault, and he allows the formation of too many crystals, the final product will be too small, may cause great difficulties in separation from the mother liquor and decrease the yield; if the number of crystals formed is too small the resulting end product will be too large, the time for crystal-

lization will be longer and again the yield will be reduced. In both instances the cost of production is increased.

But even at best the crystal formation at the time of graining is not instantaneous, and by the time that some have reached a visible size others are at the point of formation, therefore infinitely small, with the result that the final end product is not uniform in size. This is objectionable, not only on economical grounds as the difficulty of separating the sugar crystals from the adhering mother liquor is greatly increased by uneven grains, but, also a fastidious consuming public demands not only a pure, white, sparkling crystal of a certain size (varying somewhat in different parts of the country), but the crystals must also be fairly uniform in size.

The above points out briefly some of the problems in connection with producing the "granulated" crystals usually found on our markets. Not all of the sugar produced is, however, so directly obtained as granulated. Much of the final output is first obtained as a "raw" or impure sugar, which is melted, reprocessed and recrystallized. The liquors from which these raws are obtained are of a lower purity and therefore present greater difficulty to crystal formation or "graining." The impurities present, however, must not be above a certain ratio to the sugar present or crystallization in the pan will be entirely prevented and the mass will be blank or if crystals form they will remain so small as to be separated from the surrounding mother liquor only with great difficulty, if at all.

Eventually a final liquor, molasses, remains, which, in beet sugar manufacture, may contain 50 per cent of sucrose but also sufficient of impurities to prevent further crystallization. Any procedure, therefore, which increases the quantity of sugar recoverable by direct crystallization, or which increases the yield with each crystallization, or reduces the time element; or even merely simplifies the procedure may be very valuable. The saving may amount to only one hundredth of a cent per pound of sugar, and yet on the quantity of sugar produced, run into astonishing totals.

A very valuable recent development in the art of boiling sugar is the "seeding" of the saturated mass in the vacuum pan with sugar dust, to serve as nuclei for the sugar crystals, instead of the method above described of bringing about spontaneous crystal formation or "graining" by high supersaturation. Considering the simplicity of the use of sugar dust for this purpose and that it can be used without any expense or alteration of any kind in the equipment, this method is likely to prove to be one of the

most valuable developments introduced into the industry in recent years.

While the method of "seeding" herein considered is a recent development, yet the principal underlying it is not at all new.

In U. S. Patent No. 489879 dated January 10, 1893, covering a Process of Obtaining Sugar, are found the following:

"It has, however, long been known that if such impure solutions are brought in contact with a sufficiently large number of crystals, a very effective crystallization can be brought about in the vacuum pan; and this knowledge has been made practical use of in sugar factories by the addition of raw sugar crystals to juices which could otherwise only be boiled with great difficulty. Similarly it is sometimes customary in sugar refineries, when very small crystals are desired, to bring the liquor to the crystallization point, and then by the introduction of a quantity of finely pulverized sugar to start energetic crystallization, thus insuring the formation of small crystals by shortening the time of boiling and consequently that given to the crystals in which to grow."

Similar references to "seeding" sugar can be found at even earlier dates and yet it appears very doubtful that this method was ever successfully used in producing marketable sugar until less than two years ago.

To Mr. John C. Bourne, now somewhere with the Canadian forces, belongs the credit of having called attention to this subject, which led to the present development. Mr. Bourne was not familiar with the literature of the subject and was not aware that the idea had ever been suggested, to him it was entirely new.

The method as at present used very successfully, is as follows:

The sugar bearing syrup properly prepared is introduced into the vacuum pans and under the usual conditions of vacuum and temperature is concentrated till the point of saturation has been passed, that is, till the solution is slightly supersaturated or in the language of the industry, till it reaches a light "string proof." At this point a quantity of sugar dust, or powdered sugar varying from half a quart to two quarts for each 1000 cubic feet of vacuum pan capacity is introduced by aspiration, through suitable connection, beneath the surface of the boiling mass, care being taken to prevent the inrush of any considerable quantity of air as otherwise a portion of the sugar dust introduced is likely to rush up with the air and on into the condenser. This operation requires not more than half a minute. One or two minutes are required for the sugar particles introduced to mix through the boiling mass. For several minutes after the introduction or "seeding" the usual "proof" will appear blank or at

best simply show a cloud, the sugar particles introduced being too small to be visible to the naked eye.

The solution, however, is supersaturated and is boiling vigorously and the crystals or fragments of crystals introduced immediately begin to grow and soon show on the "proof." Evaporation is continued till about that density is reached usually obtained by the older methods of "graining." From here on the procedure is as usual except that experience has shown that less difficulty will be experienced to keep out false grain or "smear" in a "seeded" pan than one "grained" by the older method.

The essential difference between the two methods is that in the one case the crystallizing nuclei are introduced ready made, in the other are formed spontaneously by highly supersaturating the liquor which carries with it certain objectionable features as previously pointed out.

The quantity of sugar dust to be used per unit volume of pan capacity is dependent on the size of the dust particles and on the size of crystals required in the finished product.

In the writer's experience the "seed" used was such sugar dust as accumulates in the usual dust collectors of the sugar drying equipment. In size the dust particles ranged from an impalpably fine powder to particles just passing through a standard Tyler sieve of 100-mesh. Particles larger than this were screened out. In some instances powdered sugar as found on the market was used with success.

As a great difference in size or volume exists between particles or crystals just passing through a 100-mesh sieve and particles impalpably fine, it was considered that perhaps superior results would be obtained if the dust or "seed" used was more uniform in size. With this thought in mind trials were made with dust from which both the coarser and finer materials had been removed; improved results were not obtained if only the seed did not contain too many particles larger than 80-mesh.

Now while at the time of seeding a vast difference in size and weight exists between a powder particle and a particle of 100-mesh, when these nuclei have reached the market size little difference exists. In all probability the rate at which the crystallizing sugar deposits on the nuclei is in direct proportion to their surface areas. The surface area of an impalpably fine particle in proportion to its volume is so immensely greater than that of a particle of 100-mesh that as the two particles grow, the smaller growing at a relatively faster rate than the larger, the difference in size will become negligible.

Then, also, possibly the tendency of crystal splinters to regenerate the original shape of the crystals from which they have

been produced may play a role, as the finer particles especially are largely crystal splinters.

This describes briefly the new method of "graining" sugars in the vacuum pans as practiced for the first time during the past campaign in a dozen or more beet sugar factories of the Western States. It deserves further study before all the factors are determined. However, the results obtained during the past campaign, in the factories coming under the writer's observation, especially on the lower products, were uniformly superior to the normal results. [R. S. N.]

FILTRATION OF MUDDY JUICE IN JAVA SUGAR FACTORIES USING THE DEFECATION PROCESS.*

By A. Schweizer and G. Loos.

Certain factories using the ordinary defecation process had Kelly presses installed, and it was found, contrary to what had been experienced in defecation-sulfitation houses, that the capacity of the filters was not as great as expected, the difficulty being principally in sweetening off, but also in dropping the mud from the frames and in cleaning the cloths. Efforts were made to improve matters by the addition of materials such as fine carbon to the mud, but unavailingly. Suspecting that the absence of crystallized calcium sulfite might account for the difficult filtration, liming and sulfitation of the muddy juices was carried out, using 10-14 liters of 15 Baumé lime cream to 1000 liters of juice and sulfiting to neutrality to phenolphthalein. This treatment was entirely satisfactory, results analogous to those obtained in defecation-sulfitation factories being thus obtained.

[R. S. N.]

* Chem. Abstracts. Vol. 12, page 2257. From Java Archief.

WEED CONTROL BY POISON.

Investigations are being conducted with various herbicides for the control of weeds at the California Experiment Station, according to Mr. Geo. P. Gray. He deals with the subject in "Science" of October 4, 1918, as follows:

"Sets of experiments have been conducted in five localities, some of which have been under observation for more than two years. These investigations have furnished some very interesting data, both from the practical as well as from the scientific standpoint, the results of which are to be soon published as a progress report.

"At first thought, it may seem strange that a study of herbicides was assigned to a chemical laboratory heretofore devoted to the study of insecticides and fungicides. A careful analysis, however, of the toxicological problems encountered in either case discloses a very close correlation of certain phases of the work.

"The accumulation, classification, and otherwise making available of an accurate and complete knowledge of the source, manufacture, composition, and properties of the poisons used for the control of insects, fungi, weeds and other pests is work for which the chemist has been trained. When any of these poisons are to be used upon vegetation for the control of insects or fungi, it is fully as important to know their action on plant tissues as their action on the pest, in order to avoid the use of any remedy which may seriously injure the plant. Certain of these poisons can be used at certain times of the year only, or upon certain plants only; others are suitable for use under restricted climatic conditions. Some of these facts are directly applicable to the problem of weed control by means of chemicals. The materials to avoid in the first case may be just the ones to use in the latter case. These observations may be well illustrated by referring to some of the results of this laboratory's herbicide investigations. It is a well-known fact that soluble arsenic (except in very small amounts) is not permissible in any spray which is to be applied to cultivated plants on account of the danger of foliage injury; a completely soluble compound of arsenic was found to be the most effective of any chemical tried for the destruction of weeds. Unpublished experiments by Mr. E. R. de Ong and the writer, testing the action of petroleum oils on foliage, indicated that the constituents of petroleum distillates which are capable of removal by refining with sulfuric acid are very much more toxic to foliage than other constituents; a by-product of oil refineries, containing these highly toxic constituents, was found to be a very effective herbicide."

METHOD OF BURNING FUEL OIL.*

CARE REQUIRED TO PREVENT WASTE OF OIL.

A coal fire in the hands of a lazy or incompetent fireman may indeed fall far below the desired standards of excellence; but it can only reach a certain minimum level of efficiency, and then it will go out. Coal is, in fact, of such a nature that it will quietly stand a certain definite loss in economic results, and then it will quit.

With oil there is no limit to the possible wastefulness that may exist. Give it poor burners, improper furnace conditions or not enough draft, and it will smoke and sputter and drip oil and waste itself away, but never give up. Give it too much air, a hundred times too much, and the fire will burn, the oil will disappear, the flame will be bright, there will be no smoke; but the waste may be so great that the boiler will not make enough steam to run the feed pump, even with the best furnace and burner arrangement.

It is approximately true that 1 lb. of oil equals 1½ lb. of coal in actual steam-making results. Roughly, this is equivalent to saying that 200 U. S. gal. of oil equals one ton (2240 lb.) of coal, or one ton of coal equals about 4½ bbl. of oil.

A very handy rule, but like the rest only approximately correct, is this:

> When the price of coal in dollars per ton (2240 lb.) is double the price of oil in cents per U. S. gallon, the cost of fuel for producing a certain boiler capacity will be the same for both fuels. Thus two-cent oil equals $4 coal, or four-cent oil equals $8 coal.

This rule takes into consideration the probable increased boiler efficiency obtainable with oil, but makes certain assumptions concerning the heat values of the two fuels and the weight of the oil per gallon which, while generally representative, may or may not be correct in any specific instance.

Generally speaking, one oil burner will be required for, say, 350 to 400 boiler hp., and one oil fireman can attend to about ten burners.

Reliable tests with oil fuel have shown that the boiler efficiency (*i. e.*, the percentage of heat units in the oil which is actually absorbed by the steam leaving the boiler) may be as high as 83 to

*Journ. Am. Soc. Mech., Eng., July, 1918.

84 per cent, although 78 to 80 per cent may be considered as good work, or even 75 per cent, in regular operating conditions. With coal fuel, while reports have been published by some pseudo authorities showing over 80 per cent, the writer believes that such high results with coal can only be obtained with very large boiler units and the most efficient mechanical stokers. Certain it is that in hand-fired plants, 75 per cent is about the maximum, while 65 per cent may be considered very good average work.

The advantage possessed by oil in respect to increased efficiency is due primarily to the small amount of air required for complete combustion in excess of the theoretical amount. This may be reduced to 10 per cent with oil, while the best tests with coal, hand-fired, show about 50 per cent, and good every-day working conditions run as high as 80 or 100 per cent.

MAINTENANCE LESS WITH OIL THAN WITH COAL.

Maintenance charges are decidedly less than with coal. It is true that higher furnace temperatures with oil as a rule require a better quality of firebrick, and danger may result to boiler heating surface with improper furnace arrangements and burners. These points are easily cared for.

The theory of burning oil is different and radically distinct from that controlling the burning of solid fuel. Pulverized coal of course in some respects closely approaches the character of burning oil, but coal fired by hand or by stokers remains substantially at rest during combustion, and the air is brought to it. In the case of oil, the fuel is moving and the air moves with it.

In varying the rate of combustion of coal, the amount and velocity of the air through the fuel bed is altered—the intensity of the draft is increased or decreased. In the case of oil, the amount of fuel itself and the rate at which it enters the furnace must be varied, and the amount of air entering with it must be increased or decreased to preserve the proper ratio.

The lighting of an oil fire is a simple process. The oil pump is started to give the necessary oil pressure at the burners. The draft is opened to provide sufficient air for combustion. A lighted torch is then placed directly under the burner tip, and the oil is then turned on. If the oil is at the proper temperature and the atomizer is working properly, the spray at once bursts into flame. The spray must never be started without first lighting the torch; *i.e.*, no oil must be injected into a "dark furnace," for if it is, an explosive mixture may be formed in the furnace which will cause damage if ignited.

There is little or no difference in the action of compressed air and steam in atomizing oil as far as boiler work is concerned, and

if the air is compressed to over 30 lb. per sq. in. there is no special difference in the design of the burner itself.

So far as the steam-boiler furnace is concerned, however, the prospective user of oil may forget the air atomizer, the one instance in which its use might be considered being that in which the saving of fresh water (consumed by the steam atomizer) is a matter of importance. And in this case a mechanical atomizer will probably do the work effectively, and will be preferred.

SELECTION OF TYPE OF BURNER.

As between the claims of the steam atomizer vs. the mechanical atomizer, the issue is not as clear cut. On board ship, except in the case of harbor vessels or those making port every day, the steam atomizer has given way to the mechanical atomizer, where the saving in fresh water for the boiler makes the use of the latter type practically imperative.

There is practically nothing to choose between the two types in operating results under equivalent conditions. The steam atomizer is, however, more flexible, *i. e.*, the individual burner has a greater range in capacity; it costs less to install, notwithstanding that it requires two lines of pipe (oil and steam), whereas the mechanical uses only one, and that for the oil. It is more readily applied to a coal-burning furnace, and conversely the furnace is more quickly converted back again to coal. It requires a lower oil pressure and not so high a temperature for viscous oils. It will also, in general, require less draft to operate. Furthermore, where special arrangements of burners are required, as in the case of the so-called "back-shot" burner (placed at the rear of the furnace), the steam atomizer is susceptible of a wide range in design which has been found useful.

OIL PRESSURE AND TEMPERATURE.

For steam (or air) atomizing burners, oil pressures of 25 to 50 lb. at the pumps are adequate, and under certain conditions even less pressures. Overhead tanks a few feet above the burners, feeding the oil by gravity, have been employed, but this is inadvisable on account of danger of fire, and pumps are usually employed. Mechanical burners require pressures of 50 to 250 lb. at the burner tip, 200 lb. being a favorite pressure for the designer. The wide range of pressure is a necessity for oil burners, a vital necessity for mechanical burners. Therefore large air chambers on the oil line are needed if the usual duplex reciprocating pump is used. Rotary pumps are being introduced in the Navy, and recently the screw pump has come into vogue. These pumps give

a steady pressure of oil with little or no air cushioning, and the screw pump, particularly, seems to possess great possibilities for this work.

The matter of heating the oil is rather of a mechanical nature as its importance bears on the viscosity of the oil rather than on any thermal advantage. Steam atomizers will handle more viscous oil than the mechanical type, therefore steam heaters using exhaust steam from the pumps and capable of heating the oil to 100 deg. to 125 deg. Fahr. are usually satisfactory. The mechanical burner requires that the viscosity of the oil be reduced to 8 to 10 deg. Engler to spray properly, and this means that the oil (according to its viscosity) must be heated to 120 deg. to 280 deg. Fahr. The latter temperature is required for heavy viscous oils that are appearing on the market to a greater and greater extent. In a mechanical-burner installation it is evident that the oil heater is a most essential part of the equipment.

IMPORTANCE OF AIR REGULATION.

To a certain extent the amount of air being delivered to an oil fire is indicated by the color of the flame, a very bright, intense white (so desirable with coal) usually indicating that too much air is being used, with a resulting loss in efficiency. Judging the fire by the flame, however, is only approximate; and it is better to resort to the simple device of diminishing the air supply until a light brown haze appears at the top of the chimney. This is preferable to a clear stack, as the latter gives no indication of excess air. The light haze is not at all objectionable but represents good conditions, provided—and this is a most important point—the smoke which produces the haze does not come from one or two burners only, while all the rest are working with oil. Complete combustion in the furnace (that is, combustion in which all the carbon is burned to CO_2 and no CO is present) will give an analysis with coal in which the CO_2 content, plus the free-oxygen content, will add up considerably higher in amount than an analysis of the products of similarly complete combustion of oil. The same percentage of CO_2 in the gas sample from coal indicates a much greater excess of air over that theoretically required than when oil is being burned. However, complete combustion of oil can be secured with a much lower amount of excess air than coal fuel; and it happens, therefore, that 14 per cent CO_2 in both cases represents the same satisfactory conditions in the furnace with both fuels.

The amount of air theoretically required for the complete combustion of fuel oil of course varies with the composition of the

oil, but it may be considered that about 14 lb. or 183 cu. ft. at 60 deg. Fahr. represents the average.

BOILER FURNACE FOR OIL FUEL.

In oil burning, "furnace volume" possesses a function similar to that of "grate area" in burning coal fuel. The rate of combustion of oil per cubic foot of furnace volume may be increased or decreased according to the intensity of the draft. A large furnace is necessary, therefore, if the draft is low, and the furnace can be made smaller if the draft is increased. This effect of furnace volume on the rate of oil combustion is often ignored or misunderstood; but it is of prime importance.

A high furnace temperature promotes the combustion of oil. Owing to the less quantity of excess air, oil furnaces are usually higher in temperature than those burning coal, so that good-quality firebrick with a fusing point at least 3000 deg. Fahr. should be used. Notwithstanding the higher temperature, if the burners are set and operate properly so that no flame impinges in the wall and no hard carbon is deposited, the wear and tear should not be great.

AUTOMATIC REGULATION OF FIRE.

One of the greatest advantages of the use of oil as fuel is that it is possible to regulate the firing entirely automatically. It is well known that in the modern power plant the efficiency obtained depends very largely on the personal element in the fireroom. This personal element has been largely eliminated in the engine room by making automatic the regulation of modern prime movers. In the fireroom, however, it is customary to depend entirely on the judgment of the firemen to regulate the supply of air that will insure commercially perfect combustion and give the highest efficiency. By making this regulation automatic the method of operating the plant changes, for it is then only necessary to adjust the fires at the start, and if the automatic regulator is reliable, it will keep the fires in proper adjustment for all loads.

Automatic regulators are now on the market for oil burning which regulate the quantity of oil, the quantity of atomizing steam and the quantity of air required for combustion. While the main advantage of the automatic device is that it insures the boiler operating at maximum efficiency at all times, it also has the advantage of causing considerable saving in labor.

The arrangement of the furnace is more important than the type of burner used.

The oil is usually atomized by steam. The resultant spray is burned by mixing with the proper quantity of air and distributed evenly throughout the firebox without directly striking the surfaces of the tubes and furnace walls, but also without permitting the occurrence of blank spaces which might admit a surplus of air.

There are several types of burners, between which there is little to choose. Any of them that will properly atomize the oil and distribute the flame are satisfactory. The two extremes of the scale of desirability are, on the one hand, the burner which, by the use of a slight excess of atomizing steam, gives steady and reliable service, and, on the other hand, the one where the steam passages are reduced to just the amount necessary for atomization, but which must be watched a trifle more carefully on account of plugging up at times with dirt or carbonized oil.

The steam consumption of the former type is not over 4 per cent of the boiler output, and of the latter slightly less.

The most important instrument for oil burning is a window in the roof, through which the boiler-room engineer can see the top of the stack. Smoke, of course, is always a loss, and when firing up cold boilers cannot be avoided. A more serious loss, however, is excess of air, and this can occur with a perfectly clear stack. The best firing will be done by increasing the amount of air until the smoke stops and then cutting it down slowly until a slight haze of smoke shows.

In the larger plants, of course, more scientific methods are available. Steam-flow meters, venturi meters on unit groups of boilers, and the customary stack instruments are used and pay better returns than perhaps any other part of the investment, provided always that the information obtained from them is used for the immediate correction of any deviation from normal conditions. [R. S. N.]

TETRAPHOSPHATE.*

Under this name, shortened for commercial purposes to "tetra," a new fertilizer is now being manufactured on a large scale in Italy and elsewhere. According to a publication of the Canadian Department of Trade and Commerce, it is made by

* Scientific American, December 7, 1918.

roasting natural phosphate rock powder for several hours in a specially constructed furnace at a temperature of 600° to 800° C., together with about six per cent of a powder containing equal parts of calcium, sodium and magnesium carbonate and a little sodium sulphate. After leaving the furnace the product is hydrated by cold phosphoric acid, and for practical use is mixed with sand or dry earth until the necessary strength is obtained. "Tetra" was invented by Professor Stoppani, of Bologna, in 1914, and there are now 11 plants engaged in its manufacture in Italy, besides one in Egypt. A special commission appointed by the Italian Ministry of Agriculture reports that for wheat, rice, potatoes, oats, beans and clover, the new fertilizer is much cheaper and equal if not superior to "super."

THE POTASH SITUATION.

By A. W. Stockett.*

In the last year or two potash has been very prominently before the public, and so much information and misinformation has been published that it is very difficult to present any new facts on the subject. As over ninety per cent of all the potash used before the war was in the manufacture of fertilizer, the reading of this paper before the American Chemical Society may seem somewhat inappropriate.

The writer would be prepared to go even further than the above and for the present have our labor also dependent on a foreign source in the form of interned German prisoners of war.

The prospect of becoming independent of these foreign sources after the war is promising. When the nitrogen fixation plants now being erected by the Government are in full working order, there should be a sufficiency of nitrogen. The development of our pyrite supply and the establishment of sulphuric acid plants should insure a supply at reasonable prices. The potash supply is the only weak link in the fertilizer chain, and the writer is of the opinion that it is possible to develop a domestic potash industry.

It is well known to every one that before the war the entire world was dependent on Germany for its potash supply, and this

* A paper delivered before the American Chemical Society, Cleveland, September 12, 1918.

† From The American Fertilizer, Nov., 1918.

country was importing annually about 1,000,000 tons of potash salts of various grades, containing approximately 240,000 tons of K_2O.

The enactment of the "Potash Law" by Germany in 1910, which at one time threatened to become a serious diplomatic question, first drew attention to our entire dependence on Germany for a very important element of plant food, and in 1911 Congress made an appropriation for investigating our own sources of supply. It was not, however, until Germany put an embargo on the exportation of potash salts in January, 1915, that the question became acute, and a serious attempt was made to develop our domestic sources.

The year 1915 may be said to have marked the beginning of the American potash industry, as in that year a little over 1,000 tons of K_2O were produced. This was increased to 9,720 tons in 1916, to over 32,000 tons in 1917, and it is probable that the production for the present year will reach 60,000 tons of K_2O.

At the present time over 60 per cent of the total is being obtained from natural brines, principally Searles Lake, California, and the lakes of western Nebraska. The Desert Basin and Death Valley have long been names that appealed to the general public as probable locations of immense deposits of potash. These districts have been carefully examined by the U. S. Geological Survey, and as a result it may be stated that Searles Lake is the most promising individual source of potash at present known in this country. The extent of this has not been definitely determined, but it has been estimated to contain from 10,000,000 to nearly 20,000,000 tons of K_2O, which would be sufficient to meet the entire requirements of this country for from 20 to 40 years. Two companies are operating here and one of them, the American Trona Corporation, is said to be the largest individual producer of potash in this country. The eventual capacity of this plant may reach 75,000 to 1,000,000 tons of K_2O per year. The brine from the lake is treated by evaporation at Trona, on the edge of the lake, and it is intended to ship the crude salts thus obtained to the refinery at San Pedro on the coast. The brine is of a somewhat complex composition, and the successful treatment of it commercially was an interesting problem for our chemists. Borax and soda, and possibly salt as well, will be produced, and this should assist in enabling this plant to continue operations at a profit when the price of potash becomes normal. The geographical location of Searles Lake is very fortunate, as more than 90 per cent of the pre-war supply of potash was used east of the Mississippi River. A low ocean freight rate via the Panama Canal would be an important factor in competing with foreign supplies.

The Nebraska lakes are not at present supplying nearly half of the total amount of potash produced. These comprise a number of lakes, usually of small extent, located in the sandhill region of the State. They usually consist of a shallow lake of brine, with a bottom of muck and hardpan, underlain by a sand impregnated with brine similar in composition to the lake waters. This is the principal source of the potash. It has not been found possible to make an estimate of the total potash content of these lakes, but it has been stated by the Director of the Nebraska Conservation and Soil Survey that with the plants now producing and building, the stores of high-testing brines would be greatly reduced within four years. One of the lakes that had been pumped dry has since filled up again, and it is claimed that there was no decrease in the grade of the brine. It may be, therefore, that the life of these lakes will be considerably prolonged and this is very much to be desired, as this source of potash has so far been the foundation of the domestic supply. The district is handicapped by its geographical location, entailing high freight rates to the points of demand. It is probable that eventually a central refining plant will be erected, and by producing a very high-grade product, freight rates per unit of K_2O could be reduced by one-half.

The giant kelps of the Pacific Coast ranked second as a source of supply in 1917, having produced 11 per cent of the total for that year. As this source is being described by Mr. Turrentine it will not be further dealt with here, except to point out that it would be almost impossible to locate a source that is further from the principal centers of demand, as the Pacific Coast States, including Hawaii use less than 2 per cent of the normal supply of potash.

A little over 2,400 tons of K_2O were produced from the alunite deposits near Marysvale, Utah. This was mostly in the form of a high-grade sulphate 97 per cent pure. The alunite is crushed to about ½ inch mesh, and roasted in a rotary kiln, using pulverized coal as fuel. The calcined material is leached with hot water in a closed tank at a temperature equivalent to 60 lbs. steam pressure, which takes the potassium sulphate into solution. The solution is filtered in a Kelly filter press, and the clear filrate is then evaporated in Swenson triple-effect evaporators, and the resulting crystals centrifuged and sacked for shipment. No estimate of the cost of production is available, but unless it is possible to utilize the alumina in the residue, which is not being done at present, it does not seem that potash can be produced from this source at a profit at normal prices. In Bulletin 451, published by the Bureau of Soils, entitled "The Recovery of Potash from Alumnite," by Messrs. Waggaman and Cullen, the possibilities of obtaining

both alumina and sulphuric acid as well as potash, are discussed, and it was estimated that this should be very profitable at present prices, and possibly at normal prices also. Calcined alunite, containing 15 per cent of K_2O, has also been marketed in small quantities for use in fertilizers, as it has been found by experiment that this is as effective per unit of K_2O as the soluble sulphate and chloride salts. If a deposit of alunite could be discovered in the East near the centers of demand for fertilizers, it is probable that this calcined product could be produced at a profit at normal prices, but with the location of the present known deposits, the high freight rate will be prohibitive.

In the opinion of the writer, the dust from the cement kilns is probably the most promising source of a permanent domestic potash supply. As the result of a careful investigation by the Bureau of Soils, it has been estimated that the maximum amount of potash that might be recovered from all the cement works in the country would be 100,000 tons of K_2O.

It is not probable that this figure will ever be reached, as some plants do not have sufficient potash in the raw mix to make its recovery profitable, and others for various reasons would not find it advisable to install plants. It does not, however, seem unreasonable to expect that the amount from this source should reach 50,000 tons of K_2O per year, which is 20 per cent of our normal requirements. The geographical position of the cement industry is exceptionally fortunate, as approximately 70 per cent of the total amount of cement manufactured is produced east of the Mississippi, and this region consumes approximately 90 per cent of the normal supply of potash. The first cement plant to recover potash from the kiln dust was the Riverside Portland Cement Company, of California. Owing to litigation with the fruit growers in the vicinity, who claimed that the fine dust escaping from the kilns was causing damage to the fruit trees, the company was compelled to take steps to abate the dust nuisance. A Cottrell electrical precipitation plant was installed, and when the dust thus collected was analyzed, it was found to contain about 10 per cent of K_2O, so that at present prices of potash this is a very profitable part of the plant. The installation was completed early in 1913, and has been in continuous and successful operation ever since, so that there is no longer any question about the practicability of this method. By the end of this year there will be about a dozen cement plants recovering potash from the kiln dust, with a probable production of 10,000 to 12,000 tons of K_2O per year. The recovery of the maximum amount of potash and its concentration from the flue dust involved some very interesting chemical problems, which appear to have been successfully solved. Pub-

lished figures show that potash can be produced profitably from this source of supply under any conditions.

Another source which has even greater possibilities than the cement plants, although up to the present but very little has been done, is the dust from the blast furnaces manufacturing pig iron. Mr. R. J. Wysor made some investigations and experiments at the plant of the Bethlehem Steel Company, and it was found that with the Cottrell electric precipitation, practically all the dust and fume entering the treater could be precipitated successfully. In many cases the iron ore used in manufacturing the pig iron contains sufficient potash to make its recovery profitable, with the additional great advantage of cleaner-gas for use in the stoves and boilers. The amount of potash available from this source has not been definitely estimated, but it is probable that it would be from 200,000 to 300,000 tons of K_2O per year.

As far as the writer has been able to learn, there is at present only one plant being installed at any of the blast furnaces for the recovery of potash. All of the manufacturers are at present so intent on producing the maximum amount of pig iron that there is very little possibility of getting them to realize the importance of developing a domestic potash industry.

Another source which promises a small but permanent supply is the waste from distilleries where molasses is used to produce alcohol. This source ranked third in 1917, with a production of 2,800 tons of K_2O. Recent improvements in methods are claimed to have reduced costs and increased the potash extraction, and as this is practically a by-product it is probable that potash can be produced at a profit after the war.

There are some thirty or forty small producers of potash from wood ashes, mostly in Michigan and Wisconsin, but the total amount from this source is only about 400 tons of K_2O per year, and it is not probable that they will be able to continue operations under normal prices.

The greatest potential sources of potash are the potash-rich silicate rocks, and of these the most promising are the greensands of glaconite of New Jersey, the Cartersville slates of Georgia, and the leucite rocks of Wyoming. Any of these sources would be capable of supplying our entire requirements for many centuries. Many patents have been issued in the last fifty years for method of extracting potash from these silicates, but no general commercial process has yet been developed. Several companies have been experimenting on the greensands on what may be called a commercial demonstration scale, and claim that under normal conditions they will be able to produce potash at less than $1 per unit of K_2O.

Another company is operating on a small scale on the Carters-

ville slates, and producing a material containing 4 per cent of water-soluble K_2O, which is being used locally as a fertilizer. Experiments have also been carried out on the leucite rocks, which give promise of being successful.

The development of a commercially successful process of treating the silicate rocks would solve the potash question permanently, and this problem should not be beyond the skill of our chemists and metallurgists.

In conclusion, the writer is of the opinion that the sources of potash already discovered are sufficient to supply the requirements of this country, if sufficiently developed. He also thinks the prospects of this development are favorable, but it will probably require some kind of assistance by the Government. This might perhaps best be done by subsidizing the domestic industry to a suitable degree. In this way, the cost to the Government would be moderate and the expense would be distributed, and it would thus be possible to break the German monopoly without placing a hardship on any particular class.

STORAGE OF SUGAR DURING THE RAINY SEASON IN JAVA.*

By Dr. H. C. Prinsen Geerligs.

The Java sugar crop is harvested during the dry season and since in ordinary years the greater part of same is shipped off immediately, only a small portion is left over during the rainy season. The sugar merchants have, as a rule, already bought the sugar beforehand and chartered the necessary vessels to carry it off, so that in a very short time after the grinding of the cane the cargoes of sugar commence to leave Java. Consequently it was not necessary to keep a large store-room in the island. The sugar houses send off daily the sugar which they have made the day before and are generally rather embarrassed, when, owing to some circumstance or other, the regular transport meets with difficulties and the sugar has to be retained during a few days.

The situation at the shipping ports is somewhat better, and spacious and excellently built storehouses or godowns are found, in which the sugar can be kept awaiting shipment, but, at any rate, their capacity is only calculated to the quantity which awaits the arrival of the chartered ships and cannot contain unlimited

* Abridged from article in La Planter, April 27, 1918.

supplies. It is, therefore, evident that when the 1917 crop could not find immediately the necessary tonnage to become transported, the sugar manufacturers were at a loss to store their sugar, the crop of which in that particular year happened to be a very considerable one. It was not only sufficient to store the sugar during a short time of the dry monsoon, till the ships had arrived, but it was necessary to keep the product very probably during a long time under conditions where it was necessary to protect it against the evil consequences of a tropical rainy season.

Official reports state that in the beginning of the present rainy season still one million tons of sugar were lying in the Java warehouses, while under normal circumstances only a quarter of that quantity was awaiting transport at that time. It is, therefore, evident that the available store-room was not sufficient to protect so much sugar against the influence of the moist weather and that in many places emergency sheds had to be erected in order to supply the want.

The problem how to store uncommonly large quantities of sugar is, therefore, not only important for the 1917 surplus, but perhaps for the total crop of coming years too, so that it is highly interesting to state what the opinions of Java experts have been on this point.

On the 30th of August, 1917, a meeting was held at Sourabaya of chemical advisors of sugar factory companies and the chemical staff of the Experiment Station and other experts, with the aim of discussing the measures to be taken in order to prevent deterioration of sugar stored during the rainy season, which assembly came to the following conclusions:

The cause of the deterioration of sugar during its storage in the rainy monsoon is formed by the combination of attraction of moisture and the action of micro-organisms. The water attraction as such would be harmless, if it did not make conditions favorable for the action of micro-organisms, which action is very deleterious. By this action arise hygroscopical bodies which attract still more moisture from the atmosphere; the bacteria get still more active and the result is the leaking out of a partly inverted sugar syrup and a great loss.

The evil may be combatted by sending the sugar from the factory in a dry state and by keeping it dry during storage or by killing the germs by means of disinfectants. Up to now only the first-mentioned remedy has been resorted to, viz.: The restriction of the moisture content, which keeps down the micro-organisms as far as possible, but this is not always an easy matter to perform.

In regard to the other alternative, years ago extensive experiments were taken in that province, but without much avail. It

has been found that well-nigh all sugars are more or less infected and therefore, apart from infection from the outside, they are liable to deterioration as soon as circumstances become favorable for the development of the germs. This proves also that disinfection of the material used for packing the sugar is not a remedy.

In practice the only remedy to combat deterioration will greatly depend on the problem how to protect the sugar against moisture. All advice given concerning the building of sugar stores emphasizes the use of impermeable material for the floors, walls and roofs and making all openings, and doors, windows and ventilators absolutely fitting in order to reduce to a minimum all penetration of rain water. In normal times this is quite feasible but in this time of war, in which numerous materials are either not to be purchased at all or only at prohibitive prices, it is impossible to meet all requirements. Further most of the warehouses are already full and one cannot empty them now in order to make improvements, so that the existing ones have to be kept unchanged and the suggestions made may be applied to the construction of new ones.

The manufacturer starts the good work by delivering his sugar as dry as possible; the white plantation sugar and the refining crystals basis 98 are already exempt of moisture, while the raw basis 96 is dried with hot air as far as it can be done. Whenever it has been found necessary to wash the sugar in the centrifugal, cold water from the hot well, that means distilled water, is to be used and under no condition water from a river or other water course, in order to prevent, as much as possible, infection with micro-organisms. The dried and cooled sugar is carried to the sheds or to the shipping places in closed, or at least covered, trucks, in order to prevent moistening by rain.

When building the sugar storehouses the greatest care ought to be bestowed to the obtention of impermeable floors. Many warehouses at the coast have a floor which is at a higher level than the surrounding land, while it is encircled by a deep drain in order to carry off as much water from the soil as possible. Next, the bottom of the interior is dug out to a depth of three to six feet and the hole thus obtained filled again with dry sand, on this layer a floor of big logs is laid, the interstices of which are filled up with sawdust, in this way forming a kind of inlaid floor. A thatchwork of bamboo and palm leaf mats cover that, and on the top of this covering the high piles of sugar bags are stored. In other places one finds only a deep layer of sand, which is renewed from time to time, and, that the more so, because the pressure of the heavy bags lowers the level of the floor, which has to be brought to the former one by addition of sand.

Again in other places concrete floors are made, but they are very expensive and require much time to become perfectly dry and even then it seems that their understructure allows moisture to pass and to moisten them, since in many spots wet patches are visible even on floors of many years' age, which are detrimental to the conservation of sugar stored there. Asphalt floors do not show this phenomenon, as they completely shut off the subsoil water. It is, however, necessary that such floors rest on a very strong understructure in order to prevent fissures and to that same end the precaution should be taken to render the asphalt elastic by a liberal application of petroleum residuum to the mixture.

Warehouses with corrugated iron walls are far less liable to cause moistening of the sugar bags than those with brick walls. Corrugated iron is the best material for roofing such warehouses.

The piles of sugar bags ought to have as little surface exposed to the air as possible, therefore, they must be high and large and, as we said before, they have to be covered by mats or impermeable paper against leakages. Especially the spots opposite the doors, windows or ventilators, where, by some fissure, rain could penetrate, the mats or thatchwork should be placed so as to prevent moistening, while the pile should not touch the walls but keep distant at least one to three feet, in order to have free circulation of air between the wall and the sugar. The piles should remain untouched and should not be shifted, for if once a beginning of infection should have occurred in one place, this would be spread over the whole pile if the bags were shifted.

Finally, it is necessary to ventilate the warehouses in order to remove the vapor which might be assembled by the evaporation of moisture which has entered through the roof or the floor or the walls. It has often been suggested to leave no openings at all in the warehouses, because it was observed that sugar got moist opposite the windows or doors, so that if they did not exist the sugar could not show moist spots at all, but this is no remedy against moisture having penetrated through the smaller openings, such as leaks, pores and fissures, so that it will be necessary to ventilate the rooms at proper times. The hygrometer shows when the atmosphere outside the shed has a lower water content than inside, and at that time one should ventilate his warehouse and after that shut all doors and windows. In Java the best time to do this is between 6 and 10 a. m., because generally at these hours the absolute humidity is lowest. This is, of course, no fixed rule, as when it rains that rule does not apply and, therefore, no fixed rules can be given, but the readings of the hygrometer should give the necessary indications.

The measures to be taken against deterioration on storage during the rainy season may be summed up as follows:

1. Make a product of as good a quality as possible.
2. Dry it as far as possible.
3. Apply the greatest cleanliness in manufacture.
4. Do not transport to the coast, as long as the storeroom in the factory can be used. (This is because in general the humidity of the atmosphere at the coast places is higher than in the interior of the island.)
5. Store sugar in well-floored, well-built and well-covered warehouses which can be ventilated.
6. Ventilate by preference in the morning between 6 and 10, but only at times when the absolute humidity outside is less than within.
7. Disinfect with formol vapors.
8. Dry the atmosphere in the sheds with unslaked lime.
9. Analyze the sugar of the piles from time to time in order to see if something occurs which makes the application of other measures necessary. [R. S. N.]

VALUATION OF RAW SUGAR.*

By W. D. Horne.

In the sugar trade it has long been customary to buy and sell raw sugars on their polarization, adopting usually a basis of 96° for centrifugal sugars and 89° for muscovado and molasses sugars. For every degree above the basis a certain additional increase is paid, while for each degree below the basis a double deduction is made.

This system, while based on practical considerations and having much to recommend it, is still far from satisfactory, because it does not take sufficient account of the many influences on refining of sugars introduced by their endless variations.

Efforts have therefore been made in recent years to attempt a rough standardization of raw sugars on the part of some of the advanced manufacturers. Such methods consist of grading the sugars according to the size of grain, hardness of grain, cleanliness of solution, odor, and reaction, as well as polarization and moisture, with perhaps some other determinations.

Admirable as these facts are, they still fall far short of what is desired, for they are based on assumptions which frequently are

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not borne out in practice and entirely overlook many important variations in raw sugars which radically affect their value for refining purposes.

It is the object of this paper to direct attention to the practical considerations involved in valuation of raw sugars for refining purposes and to suggest some amplifications of the tests applied, with the hope that it may lead to a full discussion of the subject and in the belief that closer attention to the points involved must inevitably lead to greater efficiency of manufacture with a consequent decrease of wasteful operation in both manufacture and refining.

The refining value of a raw sugar depends upon its content of sucrose and the availability of that sucrose, as modified by the nature and quantity of the impurities. The nature of the impurities will determine the ease of their separation from the sucrose during refining.

Refining consists principally of (1) affination or washing the residual mother liquor of the raw sugar massecuite from the solid grain of the sugar; (2) defecation and filtration, to remove insoluble substances and some soluble impurities from the solution of the washed sugar or from the dilute washings; (3) decolorization by boneblack or other means; (4) crystallization and separation of pure sugar from the other constituents.

The response of any raw sugars to tests for the first three of these operations can be determined readily by operations herein described, giving a far closer grading of the sugar in its refining value than by the data at present supplied.

The proposed tests are novel only in some details and in their immediate application to a precise valuation of raw sugars on a strictly mathematical and therefore scientific basis.

The object of washing the raw sugar is to remove the film of low-testing molasses from the surface of the grains. A 96° polarizing sugar is usually crystallized from a solution having a purity of something less than 80, and the separation of the sucrose in crystals leaves a mother liquor of between 60 and 70 purity. Purging the massecuite in centrifugals removes, it is true, a large part of this syrup, but unless the sugar crystals are sprayed with water or a sugar solution in the centrifugal machine, an appreciable amount of this mother liquor remains adherent to the crystals.

As the object of refining is to separate the impurities from the sugar as promptly and thoroughly as possible, the first operation of refining consists of washing this residual mother liquor from the faces of the sugar crystals, and the condition of the crystals is a factor of great importance in this purification. An even grain of large size is the easiest to cleanse. Small crystals present rela-

tively more surface than larger ones, carrying more syrup, requiring larger amounts of wash water, and present greater resistance to the purging of the sugar. They also dissolve more freely in the wash water or sugar solutions used for mixing and washing, thus decreasing the yield of washed sugar and increasing the amount of washings. This carries relatively pure sugar off into impure washings and increases the labor of its recovery. Small grained sugars are slow to purge and are a detriment to rapid work.

Clustered grain is another objectionable feature as these conglomerates hold a certain amount of low mother liquor which refuses to wash out.

The purity of the grain itself is of fundamental importance for if that is not of high test, no amount of washing will yield a washed sugar of the desired quality.

All raw centrifugal sugars should be boiled from clean solutions of sufficient purity to insure a nucleus of the purest type, ranging over 99 in test. This can best be done by starting grain on concentrated juice, building up later if need be with syrups or mother liquors from other sugars.

If a second or third sugar is used as seed grain the resulting crystals will contain more impurity and can never be washed up to the highest purity.

One of the best attempts at regulating the production of raw sugar so as to meet reasonable requirements of refiners, has been made by the Cuban-American Sugar Company. Their tests include size of grain, taking a diameter of a little less than a millimeter as standard; hardness of grain, as observed when rolled between the thumb and finger; odor, divided into normal, musty, fruity, and sour; cleanliness, as indicated by the milligrams of insoluble matter per 100 g., or by the turbidity of 5 g. dissolved in 25 cc. of water, as well as polarization and moisture.

The hardness of grain is at best a questionable factor. Its solubility is what counts, and the smaller it is the more it dissolves. The refiner wants to know what yield will be had of washed sugar in washing any particular sample and how pure the washed sugar will be. The more directly and accurately these facts can be determined, the more useful the information will be.

In working out this question the matter of first importance was to adopt the proper liquid for washing the raw sugar. Water is not suitable as it dissolves too much of the grain. A pure sugar solution has the objection of tending to obscure the difference between high and low sugars through adding to each approximately the same absolute amount instead of the same relative amount of pure sugar. What I have found to be more satisfactory is a saturated solution of the raw sugar itself. This has the advan-

tage of dissolving none of the grain and removing practically all of the mother liquor from the crystals, and finally of altering to a minimum degree the purity of the washed sugar. The only other method would be to use an alcohol washing method or its equivalent, or to use a syrup or molasses obtained by working back and washing several times, both of which are too slow. The low molasses also becomes too viscous to use to advantage.

The method used is to mix 100 g. of the raw sugar with 45 cc. of water, shake 10 min. to saturate, let settle, and decant 92 cc. of the resulting solution upon 200 g. of the raw sugar. This is well mixed into a magma and purged in a small laboratory centrifugal.

In the experiments here referred to, a 5-in. cyclone centrifugal has been used, with which about ½ min. is needed to get up full speed. Two minutes' steady running after this is all that is needed, making about 9 revolutions of the handle shaft each 10 seconds.

The sugar is thus made comparatively dry, and the yield of washed sugar is found by weighing the basket with the purged sugar in it.

The sugar is then removed, dried 2 hrs. at 98° C. in a water-jacketed air bath, and polarized. A good centrifugal sugar, not mixed with seconds, will polarize about 99.4, which, of course, is the purity of the washed crystals, and the ordinary centrifugal sugars, such as constitute the greater part of the present-day supply, will have a purity of at least 99°. This is in exact accord with refinery practice, showing that the method above described gives as pure a washed sugar as that obtained under working conditions, where clear water is used in the final washing in the centrifugals.

Washing an ordinary 96° centrifugal sugar yields washings of 75° to 80° purity, or thereabouts, and it is highly desirable that all of the impurities possible should be separated from the grain and forced into the syrup, for these two are handled separately and each additional pound of impurities that hangs back in the washed sugar necessitates just so much extra work for its final elimination. A pound of impurities will lose about 0.4 of its mass in the boneblack, and carry with its remainder about 0.4 lb. of sugar into residual syrup, having a purity of about 40°. In washings of 80° purity only about 2½ boilings or crystallizations are necessary to effect this separation, whereas in washed sugar of 98° purity 6 or 7 boilings and crystallizations with all the correlated operations will be necessary to eliminate the impurities. In a washed sugar of 98° purity, therefore, as compared with one of 99° purity taken as standard, there will be 1 per cent of the mass which will have to be boiled, etc., four extra times. It follows that each 1 per cent of impurities above the normal 1 per cent left

in the washed sugar costs the refiner 1 per cent $\times$ 4 $\times$ the cost of boiling, etc., $\times$ price per lb. of raw sugar above the basic price of raw sugar, and should be valued accordingly. Conversely, a sugar washing up to 99.5° purity under standard conditions is 0.5 per cent $\times$ 4 $\times$ boiling cost $\times$ price per lb. of raw sugar less expense to refine than the normal and should be valued in accordance.

The second point to be taken into account is the amount of defecation required and the speed of filtration. These two items are rather closely related, as no raw sugar solutions will filter clear unless defecating material be added to flocculate the fine suspended impurities into masses sufficiently large to be caught in the meshes of the filter cloth or other medium employed. Raw sugars require differing amounts of defecant and consume widely varying lengths of time for filtration.

It has always been customary to neutralize any acidity with lime added in a thin cream. Formerly the flocculation required was obtained by adding blood from slaughter houses to the solution before heating to the coagulating point of serum, then raising the temperature and causing a strong flocculation.

Later, phosphoric acid and acid phosphate of lime came into vogue and these, neutralized with lime, proved very satisfactory when using filtering bags. But the rapid work done in the beet sugar industry in filtering carbonate of lime in filter presses could not be followed in sugar refining on phosphate of lime because this precipitate is soft and chokes up the cloths when subjected to the high pressure necessarrily used in the filter press.

Now, in the past few years, a suitable defecant for use in filtering sugar solutions through filter presses has been found in the great deposits of infusorial earth at Lompoc, Cal. One vein of this deposit, after special processes of treatment, is now being largely used, under the name of Filtercel, by nearly all the refiners of the country. But despite the most careful treatment in defecation, some raw sugars will filter very slowly, delaying the operations of a refinery sometimes in an exaggerated and very costly manner. Such sugars are commonly called gummy, and frequently indeed they give an excessive amount of precipitate when treated, in solution, with an excess of alcohol and a little acetic acid. These sugars are in fact very common and their objectionable quality is quite evidently due to the improper defecation of raw cane juice, a matter that is capable of nearly complete correction, and that at almost no added expense. Some raw sugars, on the other hand, filter very slowly, although containing no excessive gummy matter, probably from high sulfates, from clay, and other causes.

In order to determine the relative filterability of a raw sugar, it has been found best to use a 45 per cent solution defecated with the minimum amount of acid calcium phosphate and made slightly alkaline with a standard sucrate of lime. Into 18.1 cc. of this solution, representing 10 g. of raw sugar, introduce 0.2 cc. of a solution of acid calcium phosphate made up to contain 1 per cent P_2O_5. This will represent 0.02 per cent P_2O_5 on the dry sugar. Then add saccharate of lime standardized against the P_2O_5 solution so as to balance it volume for volume when using phenolphthalein, until the solution is just faintly alkaline to litmus. This is heated to boiling in a test tube and allowed to settle while inclined at 45°. Other tubes are rapidly prepared in succession, using 0.03 per cent P_2O_5, 0.04 per cent, and so on, noting the minimum amount which gives a clear supernatant liquor.

After thus determining the minimum amount of defecant that will give a clear solution by this preliminary trial, one adds the indicated amount of acid phosphate and lime to 100 cc. of the 45° Brix sugar solution, heats gradually to 190° F., lets stand half a minute off the hot surface, and pours slowly in a small stream upon the top of the triple thickness of a 6-in. bag filter cloth folded like a filter paper in a 3-in. perforated brass cone,with about 625 holes per sq. in., setting loosely by means of attached lugs, in a vulcanite funnel with no stem. In about ¾ minute, when the transfer is complete, the cloth is closely covered with a watch glass. The time is observed which is required for the filtration of 70 cc. If the cloth is of the right structure this filtrate will appear clear.

Excessive amounts of defecant retard rather than aid filtration.

In the refinery the column of liquor constantly rises in the bags, while in this test the column, after the short period of introduction, constantly sinks, so that conditions are quite different, and while they cannot be directly compared, there is found to be this relation—that the slower the solution is to filter in the refinery the longer the time required for 70 cc. to pass through the small filter cloth. In sugar solutions that filter freely this test portion will run through in 5 min. or less. In medium sugars from 5 to 10 min. will be taken, while poor sugars require 10 to 15 min., and bad samples take from 15 to 20 min., or even longer.

As a very slow filtering sugar may easily increase the time of filtration in the refinery to 120 per cent of the normal, it follows that time lost may be approximated by adding 7 per cent to the normal time for each additional 5 min. in the experimental filtration test. The percentage of excess time multiplied by the price of a pound of raw sugar multiplied by the cost of normal filtration will give approximately the correction to be deducted from

the basic price to arrive at the refining value of a slow filtering sugar.

The third item to be taken into account as affecting the value of a raw sugar is its readiness to yield up its color on filtration through boneblack or on subjection to any other decolorizing process. After all, refining sugar is principally decolorizing it, and any system of standardization or valuation of raws which ignores this important feature is lacking in one of the essential details.

Sugars may be of a wide range of shades and from many causes, as the variety of cane, burnt cane, caramelization during manufacture, over-liming, working back molasses and second or third product sugars, contamination by iron salts, and so on. Some of these coloring matters are more easily absorbed than others and their absorption by different agents varies widely. For instance, the natural color of cane juice is only slightly absorbed by boneblack, while Norit absorbs it quite freely; and this latter agent takes up 95 parts of color due to the action of lime on invert sugar as easily as it absorbs 23 parts of color due to caramel.

These and other considerations render an empirical test desirable, based on general common practice. Such a determination of the decolorability of a raw sugar by boneblack, for instance, may be arrived at by dissolving 10 g. of raw sugar in 30 cc. of water, adding 0.25 g. of Filtercel and 2 g. of the best boneblack ground finer than 60 mesh, bringing all gently to a boil, and filtering through paper. A similar test, made as the first is, but without boneblack, affords the basis of comparison. After reading the colors of the filtrates either against a tintometer standard or by comparing the depths of columns to give equal colors, one may readily calculate the amount of color absorbed by the boneblack.

It will be found that a fair average sugar will yield about 75 per cent of its color in this test, and any greater amount yielded means a proportional economy in char work required, while a smaller absorption designates a larger amount of char work that will be required. One can easily calculate the amount to be added to or deducted from the basic price of a sugar to arrive at its value in respect to filterability. Thus a sugar giving up only 60 per cent of color instead of 75 per cent should have 15/60 of the normal char filtering expense deducted from the basic price to recompense for the extra expense that will be entailed in its char filtration.

Other factors might be taken into account, as the amount of ash in the raw sugar, but as under present conditions it is of less importance how much melassigenic ash there is than how much time and labor will have to be expended in refining the sugar, these factors may, for the present, be disregarded.

The extra refining expenses enumerated in the above examples are very small, it is true, and would occur in relatively few cases, but with upward of $600,000 worth of raw sugar entering the port of New York alone, daily, even small decimals add up to large aggregates and are certainly worth taking into account.

Just now there is so ready a market for all raw sugar that competition in its sale is slight, but when the present stress is over and Europe resumes her large production there will be a great surplus, with corresponding competition to sell. Then the purchaser will pick and choose what suits him best, and it is the part of caution for the raw-sugar maker to consider what class of sugars will be most desired and to manage his manufacture accordingly. It is in the hope of assisting in this very particular discrimination that these suggestions are presented.

[R. S. N.]

ON THE PREPARATION OF AN ACTIVE DECOLORIZING CARBON FROM KELP.*

By F. W. Zerban and E. C. Freeland.

Dr. J. W. Turrentine, in charge of the United States Experimental Kelp Potash Plant at Summerland, California, has for several years been engaged in working out methods for the commercial utilization of the giant kelps of the Pacific Coast. During the course of his investigations it occurred to him that the char obtained in the manufacturing process used might perhaps be converted into a decolorizing carbon. It appears, however, that this question was not taken up actively, until one of the authors of this article conceived the same idea, while engaged in a study on carbons that might be used in the cane sugar industry. At his request, Dr. Turrentine sent him some dried kelp to experiment with. In the first test the kelp, after thorough drying and grinding, was carbonized in an iron retort provided with an outlet for gases, until no more fumes were given off. The char was then transferred to a closed iron receptacle and heated for 2 hrs. to a bright red heat. It was then cooled, boiled out with hydrochloric acid, washed with water, and dried. Upon examination it

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was found that the resulting carbon reduced the color of a molasses test solution to about one-third of that obtained by using an equal quantity of our standard carbon, Norit. A sample of kelp char, also received from Dr. Turrentine, when treated in a similar manner as the dried kelp, produced only a very poor carbon. We therefore decided to investigate this matter more thoroughly, and at our request Dr. Turrentine very kindly furnished us an ample supply of raw material for our further experiments, and we wish to express to him our thanks for this courtesy, as well as for the great interest he has taken in the progress of our work. The material received consisted of three different samples. The first, A, was kelp (*Macrocystis pyrifera*) dried in a rotary kiln; the second, B, was "incinerated" kelp, prepared as described below; and the third, C, was a sample made by subjecting kelp to destructive distillation. The last sample was kindly sent to us through Dr. Spencer, who was investigating the destructive distillation of kelp at the Forest Products Laboratory, Madison, Wisconsin. None of the three samples had been leached with water.

Upon investigation it was found that there are three factors which have an important effect on the properties of the final product sought. First of these is the particular point in the process at which the soluble salts and other ash constituents are removed. The second is the method by which the material is carbonized. We used two different ways with Sample A. In one experiment it was charred in an open iron saucepan over a gas ring burner, until fumes ceased to come off and the material was thoroughly carbonized. In other tests the process was conducted in a half gallon, heavy iron retort with a descending iron condensing tube about ½ in. in diameter and 3 ft. long. This was heated over a gas ring burner. Sample B, which was a char, had been prepared by feeding dried kelp into a revolving "incinerator," setting it on fire, and after it had been heated sufficiently, cooling it rapidly by quenching. Sample C was only partly carbonized, having undergone destructive distillation at a temperature not exceeding 314° C.

The third factor is the temperature to which the char, obtained by carbonization, is heated in a closed receptacle. We effected this final heating in an iron cylinder made from a nipple of 2-in. pipe, closed at both ends by screwed-on iron caps. This cylinder was placed in a muffle furnace commonly used for making ash determinations in sugar products, and which produces a maximum heat of about 800° to 900° C.

The three factors mentioned will be taken up in detail in this paper. The decolorizing effect on sugar products of the various carbons made was determined by the following method: 5 g. of

the carbon under examination are added to 200 cc. of a 3 per cent solution of a stock sample of low-grade molasses. The solution is brought just to the boiling point and at once filtered through a folded filter. The decolorized solution is then compared colorimetrically with one obtained under the same conditions, but using 5 g. of Norit instead of the carbon. The color of the solution obtained by means of Norit is used as a standard and is called "1." Carbons more effective than Norit will give figures below "1" and those less effective figures above "1." The reciprocals of the figures give a direct measure of the effectiveness of the carbon as compared with Norit.

EFFECT OF LEACHING.

A part of each sample, A. B, and C, was boiled out several times with water, thoroughly drained, and again dried. Parallel experiments were then made with both leached and unleached material. The following table gives the tests and their results:

Treatment.	Color of Solution Decolorized with Carbon from	
	Leached before Heating	Not Leached before Heating
A, charred in retort, heated to bright red heat in closed iron cylinder, boiled out with water	5.00	2.86
A, charred, heated to bright red heat, boiled out with acid, then water	2.78	1.25
B, heated to bright red heat, boiled out with water	2.56	1.37
B, heated to bright red heat, boiled out with acid, then water	1.47	0.34
C, heated to bright red heat, boiled out with water	3.57	3.33
C, heated to bright red heat, boiled out with acid, then water	1.85	1.37

The table shows that the better carbon is always obtained from the unleached material, and, in fact, the only carbon that is better than Norit, and considerably so, was prepared from material that was not treated with any solvent until after it had been brought to red heat. We may conclude from this that if our object is to make an active carbon, none of the mineral matter must be removed before heating the material to red heat.

EFFECT OF METHOD OF CARBONIZATION.

The way in which the kelp is carbonized is almost of as great importance as the question of leaching. The different methods

of charring have already been described above. It is very difficult to carbonize the kelp in the iron retort always under the same conditions on account of varying gas pressure and because the condensing tube often gets more or less clogged with tarry products, thus preventing the free escape of the fumes. The effect of these factors which were not under control is strikingly shown in the figures below:

Treatment.	Color.
A, carbonized in an open saucepan, then heated to bright red heat in closed cylinder, boiled out with acid, then water......	0.28
A, carbonized in iron retort, then heated to bright red heat, boiled out with acid, then water..............................	0.31
Same, other experiment....................................	0.50
Same, other experiment....................................	0.75
Same, other experiment....................................	1.25
B, heated to bright red heat, boiled out with acid, then water....	0.34
C, heated to bright red heat, boiled out with acid, then water....	1.37
C, first completely cabonized in open saucepan, heated to bright red heat, boiled out with acid, then water..................	1.70

These experiments show that the best results are obtained when the raw material is carbonized quickly at a comparatively high temperature and in such a way that the fumes can freely escape. Carbonization alone, however, is not sufficient to make an active decolorizing carbon, as is shown by the fact that Sample B itself, without first being heated to red heat, produced a color of 3.70 when extracted with water, and of 1.56 when extracted with acid and then washed with water. Sample C gave 3.85 and 1.72, respectively.

EFFECT OF TEMPERATURE TO WHICH THE MATERIAL IS HEATED AFTER CARBONIZATION.

Three series of experiments were made to test this question, two (1 to 4 and 5 to 8) with char obtained by carbonizing Sample A in the iron retort at low temperature, and another with Sample B as received (9 to 11).

No.	Treatment.	Color.
1.	A, carbonized in iron retort, heated to full red heat, boiled out with water....................................	2.86
2.	A, carbonized, heated to medium red heat, boiled out with water..	3.23
3.	A, carbonized, heated to low red heat, boiled out with water	3.57
4.	A, carbonized, heated to barely red heat, boiled out with water..	4.17
5.	A, carbonized, heated to full red heat, boiled out with acid, then water....................................	1.25
6.	A, carbonized, heated to medium red heat, boiled out with acid, then water..............................	1.52
7.	A, carbonized, heated to low red heat, boiled out with acid, then water....................................	1.47
8.	A, carbonized, heated to barely red heat, boiled out with acid, then water..............................	1.72
9.	B, heated to full red heat, boiled out with acid, then water 0.34 and 0.30, average...........................	0.32
10.	B, heated to medium red heat, boiled out with acid, then water..	0.62
11.	B, heated to low red heat, boiled out with acid, then with water..	1.43

We find that within the temperatures at which tests were made the best carbon is obtained by heating to the highest temperature, full red heat. It is possible and even probable that still better carbons might be prepared by heating to even higher temperatures, but this would hardly be of practical interest. One experiment was made in which a quantity of B was heated in a clay crucible in a Fletcher furnace, but observation showed that the temperature was not any higher than we could obtain with the iron cylinder in the muffle furnace. The resulting carbon, after washing with acid and water, produced a color of 0.36, which is very close to the 0.32 shown in the above table for the muffle heated carbon.

Another experiment was carried out in order to see whether a good carbon could not be made in one operation. The iron cylinder described above was filled with dried kelp, and one of the caps was only screwed on loosely so that the fumes might escape, without giving the air free access to the char. After heating to full red heat the carbon was boiled out with acid, and washed with water. It produced a color of 0.75, and was therefore much less effective than the carbon produced in two operations.

We have also found that it is not necessary to extract the carbon directly with hydrochloric acid. The water-soluble salts can first be removed with this solvent, and the greater part of the remaining ash is then dissolved with hydrochloric acid, after which the acid is again washed out with water.

Summarizing briefly, our tests have shown that a carbon which has a much greater decolorizing power than Norit can be prepared in the laboratory by quickly carbonizing dried Pacific Coast kelp in such a way that the fumes can freely escape. After they cease to come off, the char is transferred to a closed iron receptacle and heated for 2 hrs. or so to red heat. Instead of charring dried kelp, "incinerated" kelp may be used directly. The carbon is then boiled out either with dilute hydrochloric acid, or first with water and then acid. This is again washed out with water, and the carbon dried. It remains to be seen whether the process can be worked successfully and economically on a large scale, and whether the price to be gotten for the finished product will warrant its manufacture. The most logical place to work out the first problem is the United States Experimental Kelp Potash Plant in California, and we hope that the Bureau of Soils may be willing and able to take up this project.

The great decolorizing power of the kelp carbon is probably due to two factors. We had found before that active decolorizing carbons can be prepared from cellulose materials by first impregnating them with either infusible substances like lime, alumina,

silica, or else with such substances as chlorides, etc., which are volatile at the temperature at which the carbon is made. In all these cases the carbon must be heated to red heat to get good results, and the impregnating substances must then be removed with proper solvents. In the particular case of potassium chloride as impregnating substance the carbon obtained was rather poor, and the potassium chloride content of the kelp alone would not explain the decolorizing power of the kelp carbon. There is also too little infusible ash to account for it. However, a distinguishing feature of kelp is its high nitrogen content, and it seems reasonable to suppose that this is largely responsible for the great effect of kelp carbon. The great decolorizing power of carbons made from highly nitrogenous materials, like blood charcoal, or the carbon made from the residues of the manufacture of ferrocyanide and from similar materials has long been well known. We noticed that in every case where we obtained a good carbon from kelp, prussian blue was formed when the carbon coming from the muffle was extracted with hydrochloric acid. It imparted to the wash waters a deep blue color, being dissolved in collodial form. The rôle played by the nitrogen is not known definitely, but the effect of its presence is quite plain.

SUMMARY.

It is shown in this paper that under proper conditions a decolorizing carbon much more effective than Norit can be prepared from Pacific Coast kelp. The factors affecting the decolorizing power of the carbon are discussed, and a method for making the most effective carbon is described.

[R. S. N.]